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ORIGINAL RESEARCH

Real effects of capitalized research and development expenditures: a leading indicator for future innovation performance?

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Abstract

This paper analyzes the relationship between capitalized Research and Development (R&D) expenditures under IFRS and innovation performance measured by patent data. Under IFRS, development expenditures are capitalized when the success of an R&D investment is highly likely. Hence, such capitalization could be a leading indicator for future innovation performance. We analyze this question based on a hand-collected sample of R&D capitalization data under IFRS and patent data from the European Patent Office's Worldwide Patent Statistical Database. We find that the capitalization rate of R&D is positively related to future patent applications and citations as measures of future innovation performance. We also find a positive association with measures of future financial performance. The results imply that the rate of R&D capitalization is informative and can be considered a leading indicator for future innovation performance.

Keywords Earnings management · Innovation · Research and development

1 Introduction

We examine whether R&D capitalization under IFRS[1] is related to future economic benefits and analyze its usefulness as a leading indicator for future innovation performance.[2] IAS 38 stipulates that only R&D investments with a high likelihood of success are to be

[1] Under IAS 38, development expenditures are capitalized when six criteria are cumulatively fulfilled, whereas research expenditures are expensed (IAS 38.57). These criteria require economic and technical feasibility of the intangible asset, and that the firm can expect to generate a net economic benefit from the investment. For brevity, we refer to "R&D capitalization".

[2] Following prior research (e.g., Ahuja & Katila 2001; Laursen & Salter 2006; Rosenbusch et al. 2019), we define innovation performance as a firm's success in developing and implementing new or superior goods, services, processes, or organizational methods (Organization for Economic Co-operation and Development OECD, 2005, 46) that allow firms to generate economic benefits.

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capitalized. Consequently, if firms reliably estimate their R&D investments' probability of success, higher R&D capitalization rates should be indicative of higher R&D success and hence better future innovation performance. However, because the success of R&D is highly uncertain and failure is possible even in late stages of development,[3] it is difficult for firms to reliably estimate an R&D project's future outcome at the time of the investment. It is hence unclear if R&D capitalization is indeed informative about the implications of R&D investments for future performance.

Evaluating innovation performance is important for investors since they can earn excess returns based on it (Branch and Chichirau 2010; Martens 2023; Matolcsy and Wyatt 2008). Capturing innovation performance is difficult and suitable measures have been sought for in practice and academia for a long time (e.g., Hagedoorn and Cloodt 2003; Mankin 2007). R&D expenditures only partially capture innovation performance due to the high uncertainty of innovation efforts (e.g., Birchall et al. 2011; Cohen et al. 2013). Patent data is another important measure of innovation performance (e.g., Ahuja and Katila 2001; Chen et al. 2023; Griliches 1984; Henderson and Cockburn 1996), but it becomes available only after an extensive period of time (Deng et al. 1999). In contrast, R&D capitalization is readily observable at the time of R&D investment and should reflect the firm's evaluation of the project's expected economic success. In fact, the standard setter's intention for the capitalization of intangibles is to reveal the firm's private information on investment prospects (e.g., Mazzi et al. 2022; Ramanna and Watts 2012). If R&D capitalization indeed reflects this private information, then the capitalized portion of R&D will represent a leading indicator of innovation performance from which market participants would significantly benefit.[4] If we find that R&D capitalization is linked to future innovation performance, this confirms the standard setter's intention and provides a leading indicator for the prospects of a firm's R&D investment that can be used in their evaluation. However, due to the uncertain nature of R&D investments, their success is difficult to predict.

Prior research finds that R&D capitalization is associated with high uncertainty and that R&D accruals are subject to increased estimation error and low reliability (Kothari et al. 2002; Amir et al. 2007). The FASB has been concerned that although R&D expenditures provide future benefits on average, this relationship does not apply for each individual R&D project and future benefits are largely unrelated to incurred costs (SFAS No. 2). Recent research on R&D capitalization finds that market participants are skeptical of R&D capitalization and do not use the information provided by the accounting (Dinh and Schultze 2022; Mazzi et al. 2022).

The extant literature on R&D capitalization, reviewed in detail in Sect. 2, finds conflicting evidence on the link between R&D capitalization and future benefits. This literature is based on capital market studies and the premises of the efficient market hypothesis which assumes that information is correctly reflected in equity markets. However, there is an extensive literature which documents that markets deviate from efficient information processing in various ways (e.g., Benartzi and Thaler 1995; Odean 1998; Smith et al. 2000).

[3] For example, a study by Booz & Company shows that only about 1–20% of a firm's development investments are successful and reach market phase (Jaruzelski et al. 2012).

[4] Firms severely limit voluntary disclosure on innovation inputs (Graham et al. 2005; Jones 2007). Information on innovation outputs becomes public only with a significant time delay (Deng et al. 1999) so that investors are often unable to differentiate between "good" and "bad" R&D projects in the period of investment. R&D investments hence increase information asymmetry (Palmon & Yezegel 2012) and lead to mispricing of R&D-intensive firms (e.g., Eberhart et al. 2004; Lev et al. 2005), large insider gains (Aboody & Lev 2000), undervaluation, and subsequent excess returns (e.g., Ali et al. 2012; Chan et al. 2001).

Whether investors correctly perceive R&D capitalization or irrationally disregard capitalized R&D for undue fear of earnings management has not been studied yet. To shed light on this question, we investigate real economic benefits related to capitalized R&D investments rather than capital market reactions.

In contrast to prior literature (e.g., Ahmed and Falk 2009; Cazavan-Jeny et al. 2011; Lev and Sougiannis 1996), we do not use financial measures of future benefits, such es earnings, but use two more direct measures of innovation performance following prior management literature (Acs et al. 2002; Goldman et al. 2020): (1) patent applications and (2) patent citations. Earnings may capture economic benefits from R&D activities but are also subject to numerous other factors including accounting choices and managerial incentives (Jaffe 1989; Laursen and Salter 2006). It is difficult to empirically capture a relationship between R&D capitalization and future earnings, especially in industries with long innovation cycles, where innovations take a long time to convert into profit and are influenced by confounding factors over time (e.g., Gu 2005). We concentrate on patent applications and citations as measures of the real effects of R&D investment success.

To address whether R&D capitalization is informative about a firm's future innovation performance, we examine a German sample. Germany is the fourth largest economy worldwide (IMF 2023) and ranks among the four largest global R&D spenders after the United States, Japan, and China (absolute gross domestic spending; OECD 2022). Annual R&D spending in Germany has increased from 2.7 to 3.2 percent of GDP during the last decade, which is similar to the United States (OECD 2021). Consequently, Germany is a large, important economy that is home to numerous R&D-intensive firms. Of the four largest global R&D spending nations, only Germany has adopted IFRS: since 1998 firms in Germany have been allowed to voluntarily adopt IFRS for consolidated financial statements (e.g., Hung and Subramanyam 2007) and since 2005 IFRS is mandatory for consolidated financial statements of publicly listed firms. The accounting for intangibles has been one of the main discrepancies of IFRS and national GAAP. Whereas capitalization of internally generated intangibles was formerly prohibited under German GAAP, R&D capitalization has been a choice similar to IFRS since 2009, but it is still prohibited in the tax accounts. The German commercial code defines German GAAP as the basis for tax accounting and profit distribution (Ball et al. 2000), but the consolidated IFRS reports are independent from that and exclusively serve the capital market's information needs. The German capital market is well developed and Germany is typically considered to be among the countries with the strongest legal enforcement and shareholder protection among the IFRS-adoption countries (e.g., Halabi et al. 2019; Persakis and Iatridis 2017). Consequently, Germany offers a well-suited setting to observe the informational features of R&D capitalization under IFRS over a long time period. By focusing on one country, we hold country-specific factors associated with reporting incentives, and accounting properties constant (e.g., Ball et al. 2000; Leuz 2003). We use unique patent data from the European Patent Office's Worldwide Patent Statistical Database (PATSTAT) to measure innovation performance. We study both the quantity and quality dimensions of innovation performance, proxied by patent applications and citations (Ciftci and Zhou 2016; Gu 2005; Hall et al. 2005).

We find that the ratio of capitalized R&D relative to R&D expenditures is significantly positively associated with future innovation performance. This relationship is positively moderated by R&D intensity, and hence the level of capitalized R&D positively relates to future innovation performance. We further examine how earnings management incentives affect this relationship, and split our sample based on whether firms are suspect of benchmark beating. We find that capitalized R&D is only positively related to future innovation performance for non-suspect firms. Our results thus imply that the rate of capitalized R&D is a leading indicator for innovation performance, particularly when firms are unlikely to use R&D capitalization to meet earnings targets.

Our study makes two main contributions. First, we contribute to the literature on measuring innovation performance by identifying the capitalization rate as an early indicator. Proxies of innovation performance used in previous literature reflect different stages of innovation (Hagedoorn and Cloodt 2003) from innovation input (e.g., R&D expenditures), to innovation processes (e.g., project count), and innovation output (e.g., product introductions) (Mankin 2007). Between these measures, data availability varies greatly. Innovation input such as R&D expenditures is generally publicly available, whereas measures of innovation output are obtained from surveys (Cosh et al. 2012; Hagedoorn and Cloodt 2003; Ritala et al. 2015), which introduces subjectivity concerns. While some studies suggest that patents are "the most important measure of contemporary firms' innovative output" (Hirshleifer et al. 2013, p. 633), such information is not available for all firms and is published with a significant time delay (Deng et al. 1999; Ritala et al. 2015). In comparison, R&D capitalization is both timely and easily available public information. Also, R&D capitalization is denominated in monetary units and may thus be easier for market participants to interpret and relate to future economic outcomes (Gu 2005). Since capitalized R&D is positively associated with patent quantity and quality, two established measures of innovation performance (e.g., Acs et al. 2002), we add to the innovation literature by showing that the current rate of R&D capitalization can serve as a predictor of future innovation performance.

Second, we add to the literature on the accounting for intangibles (e.g., Lev and Sougiannis 1996; Markarian et al. 2008; Mazzi et al. 2022) by demonstrating that R&D capitalization under IFRS is indeed linked to future economic benefits and reveals the firm's private estimates for the success of the R&D project. Our study differs from prior literature in that we use more direct measures of R&D success and thus provide an answer to the previously unresolved question on the usefulness of R&D capitalization. Extant studies of R&D capitalization under IFRS focus on capital market effects and test for the association of capitalized R&D with future economic benefits only indirectly, based on market reactions, which are linked to investors' expectations when the efficient market hypothesis holds. Whereas prior evidence suggests that investors question the informativeness of R&D capitalization (e.g., Mazzi et al. 2022), our results imply that investors can reliably use capitalized R&D to infer future economic benefits for firms that are not suspect of benchmark beating. Since prior research finds that market participants can correctly discern whether R&D capitalization is driven by earnings management motives (Kreß et al. 2019; Dinh et al. 2016), they can identify suspect firms. These findings are relevant for standard setters and imply that R&D capitalization can benefit from measures that limit discretion in R&D capitalization.

The remainder of the paper is organized as follows: Sect. 2 presents the theoretical background and derives the hypotheses. Sections 3 explains the research design and Sect. 4 describes the sample. Sections 5 and 6 present the empirical results. Section 7 contains concluding remarks.

2 Related literature

2.1 R&D capitalization

Despite intensive research on the matter, the accounting for R&D remains a controversial issue. Advocates for R&D capitalization suggest that full expensing is misleading about the investment character of R&D expenditures (e.g., Lev and Sougiannis 1996; Penman and Zhang 2002).[5] In line with these arguments, IAS 38 requires capitalization of development expenditures when six criteria are cumulatively fulfilled. These criteria require firms to intend to and possess the resources to complete the intangible asset, and to be able to demonstrate technical and commercial feasibility, reliable measurement of expenses, and how the intangible asset will generate economic benefits (IAS 38.57). However, opponents to R&D capitalization argue that R&D investment benefits are highly uncertain (e.g., Kothari et al. 2002). More specifically, standard setters are concerned that although R&D expenditures provide future benefits on average, this relationship does not apply for each individual R&D project and future benefits are largely unrelated to incurred costs (SFAS No. 2). Consequently, U.S. GAAP prohibits the capitalization of R&D expenditures (SFAS No. 2),[6] except for software development expenditures (SFAS No. 86). Consistent with this view, prior literature documents that R&D investments lead to higher future earnings variability than investments in property, plant, and equipment (Amir et al. 2007; Kothari et al. 2002).

Only few studies investigate future economic benefits associated with capitalized R&D and are limited to national GAAP. Some studies find that capitalized R&D expenditures are related to higher future accounting performance. In a sample of firms under Australian GAAP, capitalized R&D is related to lower future earnings variability than expensed R&D (Ahmed and Falk 2009; Thomas et al. 2010). Also, reported capitalized software development costs (Aboody and Lev 1998) and as-if capitalized R&D assets under U.S. GAAP are positively related to future earnings (e.g., Ciftci and Zhou 2016; Lev and Sougiannis 1999; Penman and Zhang 2002). Conversely, Cazavan-Jeny et al. (2011) document that R&D capitalization under French GAAP is generally not or only negatively related to future accounting-based performance measures.

Most studies on R&D capitalization investigate its value relevance and hence only indirectly test for future economic benefits based on capital market reactions. Most of these studies are based on capitalized R&D under national GAAP and provide contradictory evidence. Under U.S. GAAP, capitalized software development costs (Aboody and Lev 1998) and as-if capitalized R&D are positively related to future stock returns (e.g., Ciftci and Zhou 2016; Lev and Sougiannis 1999; Penman and Zhang 2002). Outside the United States, empirical evidence indicates that capitalized R&D expenditures under some national GAAPs are value relevant (e. g., Ahmed and Falk 2006; Callimaci and Landry 2004; Smith et al. 2001) and that capitalizing firms' stock prices are more informative compared to expensing firms' (Oswald and Zarowin 2007).[7]

In contrast, a large body of literature challenges the value relevance of R&D capitalization (Ali et al. 2012). R&D capitalization was found to add to the complexity of forecasting earnings due to uncertain capitalized amounts, amortization rates, and impairment charges (Wrigley 2008), such that analysts' forecast errors increase (Dinh et al. 2015; Aboody and Lev 1998) and earnings quality decreases (Ciftci 2010). Cazavan-Jeny and Jeanjean (2006) document negative investor reactions to R&D capitalization for a sample of French firms

[5] Ali et al. (2012) find that even professional analysts are misled, and their forecasts underestimate the future benefits of R&D expenditures.

[6] Before 1975, firms reporting under U.S. GAAP could choose between expensing and capitalizing R&D investments (Daley and Vigeland 1983). Most firms used R&D expensing (e.g., Horwitz and Kolodny 1980; Vigeland 1981).

[7] Capitalized intangible assets have also been shown to be related to lower analysts' forecast errors and forecast dispersion (e.g., Anagnostopoulou 2010 under U.K. GAAP; Matolcsy and Wyatt 2006 under Australian GAAP). Dinh et al. (2015) find a similar effect of capitalized R&D on analysts' forecast errors only

and Chan et al. (2007) find that R&D capitalization is perceived as bad news in a sample of Australian firms.

Research on R&D capitalization under IFRS is limited to few studies. Mazzi et al. (2019) is the only study we are aware of that analyzes the association of future profitability and R&D capitalization, but their focus is on the influence of corruption, based on the notion that higher levels of corruption facilitate opportunistic R&D capitalization. In their sample for 2006–2010 of firms with mandatory IFRS adoption in 2005, they find a positive relation between capitalized R&D and future operating earnings, which is negatively moderated by the countries' level of corruption. Whereas their broad sample of 20 countries is well suited to study the influence of corruption, the comparison across diverse institutional and technological backgrounds over a relatively short time period impedes general conclusions on the economic benefits associated with R&D. The consequences of R&D activities typically take a long time until fruition. We therefore study an extended time frame over two decades with varying time lags and concentrate on one country with R&D-intensive firms. Moreover, we use more general measures of future economic benefits.

Most studies focus on capital market effects. Dinh and Schultze (2022) find that market participants price overall R&D expenditures rather than capitalized R&D and Dinh et al. (2016) find that capitalized R&D is only priced when firms are unlikely to use capitalization for earnings management purposes in a German sample. Kreß et al. (2019) confirm this finding for the debt market. Tsoligkas and Tsalavoutas (2011) document that capitalized R&D under IFRS is value relevant in a sample of U.K. firms, where IFRS adoption has led to a switch from optional R&D capitalization under U.K. GAAP to mandatory conditional capitalization under IFRS. Dargenidou et al. (2021) find that this regime change led to a decrease of the association between current stock returns and future earnings for capitalizing firms, which implies that capitalized R&D under IFRS contains less information about future earnings than under U.K. GAAP. Oswald et al. (2022) further find that the regime change led to a decrease in R&D expenditures for firms that switched from expensing R&D prior to IFRS adoption to capitalizing under IFRS.

These capital market studies are based on the premises of the efficient market hypothesis and assume that information is correctly reflected in equity markets. However, the literature also documents that markets often deviate from efficient information processing, including individual (e.g., Benartzi and Thaler 1995; Odean 1998) and systematic irrationality, like market sentiment and bubbles (e.g., Ciccone 2011; Shiller 1984; Smith et al. 2000). It is yet unclear whether investors correctly perceive R&D capitalization, and it truly reflects future economic benefits deriving from R&D. Reportedly, analysts are weary of R&D capitalization for fear of earnings management (AIMR, 1994; Entwhistle 1999; Goodacre 1991; Haller et al. 2008). Since evaluating the criteria for R&D capitalization under IFRS entails subjective judgment, IAS 38 leads to a de-facto choice to capitalize (Dinh and Schultze 2022; Kreß et al. 2019; Mazzi et al. 2019). Markarian et al. (2008) document that R&D capitalization is used to beat earnings targets and investors have been found to react negatively to R&D capitalization for fear of earnings management (e.g., Cazavan-Jeny et al. 2011; Prencipe et al. 2008). It is to date not clear whether market participants irrationally disregard capitalized R&D, or whether they rationally discount this information due

Footnote 7 (continued)

for firms which operate in a highly uncertain environment in a sample of German firms. Further support for the informativeness of R&D capitalization is provided by Mohd (2005) for capitalization of software development expenditures under SFAS No. 86.

to their insights into an opportunistic use of managerial discretion. Consequently, we focus on more direct measures of future economic benefits from capitalized R&D to eliminate potentially confounding factors related to the investors' information processing.

2.2 The role of innovation for firm performance

Innovation is often considered crucial for firm growth and sustained profitability (Rousseau et al. 2016). Hence, firms invest in R&D projects to become and remain innovative. However, R&D investments may fail during development or upon market introduction (Ely et al. 2003). Since R&D investments are firm specific, liquidation values in case of project failure are generally negligible (Carpenter and Petersen 2002). Future benefits of R&D investments are highly uncertain (Kothari et al. 2002; Thomas et al. 2010) and realized with a substantial time lag (e.g., Chan et al. 2001; Ciftci 2012; Duqi et al. 2011). This complicates forecasting and the valuation of R&D-intensive firms (Rousseau et al. 2016), and leads to information asymmetry (Aboody and Lev 2000; Ciftci et al. 2011; Palmon and Yezegel 2012). Since active markets for investments in innovation activities that could aggregate private information and provide efficient market prices do not exist (Aboody and Lev 2000; Gu and Wang 2005), idiosyncratic risk, stock return volatility (Chan et al. 2001; Duqi et al. 2015; Mazzucato and Tancioni 2008, 2012), earnings volatility, and earnings forecast variability (Chambers et al. 2002; Gu and Wang 2005) are higher for R&D-intensive firms.

Short-term oriented market participants often do not sufficiently value future benefits of innovation activities (Bae and Kim 2003; Hall and Hall 1993). As a result, R&D-intensive firms are often undervalued (Ali et al. 2012; Ciftci et al. 2011; Duqi et al. 2015) and provide substantial and persistent excess returns (Chan et al. 2001; Chambers et al. 2002) that compensate investors for the specific risk of R&D-intensive firms (Chambers et al. 2002; Lev & Sougiannis 1999). Investors are interested in evaluating firms' innovation performance, since innovation performance is not fully reflected in market prices and investors who are able to assess innovation performance early can earn excess returns (Branch and Chichirau 2010; Cohen et al. 2013).

2.3 Measuring innovation performance

A large body of literature examines innovation (see Adams et al. 2006 and Díaz-García et al. 2015 for literature reviews), but the results are frequently inconsistent (Hagedoorn and Cloodt 2003) due to the various indicators used to capture innovation. Identifying a generally accepted measure of innovation performance has long been a concern in both research and practice (Bhattacharya 2016; Mankin 2007). Prior literature has used R&D input, such as R&D expenditures, intermediate proxies such as patents, and output measures, such as new product introductions, and firm profit (e.g., Acs et al. 2002; Chen et al. 2023; Gu 2005; Michalisin 2001) as a proxy of innovation performance.

Prior literature documents that R&D expenditures are positively related to firm innovation (e.g., Audretsch and Acs 1991) and economic growth (e.g., Gumus and Celikay 2015; Bilas et al. 2016). However, firms with higher R&D spending are not necessarily more innovative (e.g., Hammar and Belarbi 2021; Hansen 1992) since R&D outcomes are generally uncertain and firms' abilities to generate benefits from R&D investments depend on numerous factors (e.g., Jaffe 1989; Chen 2004). Hence, R&D expenditures are considered insufficient for evaluating innovation performance on the firm-level (Chan et al. 2001; Ciftci et al. 2011; Guo et al. 2006).

Patents provide additional information beyond R&D expenditures (Branch and Chichirau 2010) and are widely used to measure innovation performance (e.g., Balsmeier et al. 2017; Cohen et al. 2013). A patent represents the exclusive temporary right to exploit an innovation (Hall 2007). Patents are directly linked to innovation activities (Pakes 1985; Trajtenberg 1990) and they are not subject to regulation and managerial discretion (Lee and Chen 2009; Zirger and Maidique 1990). Patents are value relevant (Bloom and Van Reenen 2002; Ciftci and Zhou 2016) and positively related to future excess returns (Hirshleifer et al. 2013), which suggests that patent applications quantify the value of firms' proprietary rights and ideas (Schankerman and Pakes 1986).

While patent applications reflect innovation output quantity, patent applications neglect heterogeneity in patent quality (Griliches 1990) and the value of patented innovations (Comanor and Scherer 1969; Lanjouw et al. 1998). Since the distribution of patent value is skewed to the left (Schankerman 1998; Scherer & Harhoff 2000) and the value of a patented innovation may change over time (Lanjouw and Schankerman 2004), it is important to also consider the quality of innovation performance and account for patent value (Hall et al. 2005; Pandit et al. 2011). Like academic citations, forward citations, i.e., the number of patents that refer to a preceding patent, highlight its impact and innovative contribution (Albert et al. 1991; Trajtenberg 1990). Patent citations are positively associated with firm market value (Hall et al. 2005; Sandner and Block 2011), future productivity and earnings (Bloom and Van Reenen 2002; Gu 2005), and changes in current financial performance (Narin et al. 1987). Also, patent citations are negatively related to the volatility of future operating performance (Pandit et al. 2011) and market participants value R&D expenditures more strongly when patent citations are high (Ciftci and Zhou 2016; Hirschey et al. 2001).

Overall, numerous studies document that patents provide information on innovations and use patent data as a measure of innovation performance (e.g., Balsmeier et al. 2017; Brav et al. 2018). However, information on patents is only available with a significant time delay (Deng et al. 1999). While the delay does not impede using patent data in ex post analyses of innovation, it limits its usefulness for evaluating firms' future innovation performance based on timely information.

3 Hypotheses development

Prior literature finds that innovation is critical for a firm's success, and R&D activities crucially contribute to innovation and profitability, but not all R&D is equally successful. However, timely measures of innovation performance that could help investors evaluate a firm's R&D activities are hard to find. The literature has yet to investigate whether R&D capitalization provides a readily observable measure that indicates the managements' current estimate of the future success of R&D activities. Research on the decision usefulness of R&D capitalization has focused on its capital market effects, but the evidence is mixed. In particular, market participants neglect information on capitalized R&D, but it is not clear whether these findings are due to investors' rational responses to inherent uncertainties in R&D and potential managerial opportunism, or whether investors irrationally disregard information on R&D capitalization. We address this question by examining whether capitalized R&D is related to real economic benefits as captured by patent information.

The intention of the standard setter is that R&D capitalization should reveal the managers' private information on the R&D activities' likely success (e.g., Ramanna and Watts 2012). Managers have access to more detailed and timely information than investors and may choose to share this information if they expect desirable market reactions (Connelly et al. 2011). Prior literature argues that accounting choice is a suitable mechanism to reveal private information and that R&D capitalization can signal the prospects of R&D success (e.g., Fields et al. 2001; Lev and Zarowin 1999). IAS 38.57 stipulates capitalization of development expenditures only for economically and technologically feasible projects with an expected net benefit for the firm. Under these rules, the capitalization of R&D would be legitimate only if management expects an R&D project to generate future economic benefits for the firm.

R&D investments are a fundamental step to create and boost innovation to bolster the long-term profitability of the firm (Rousseau et al. 2016). Prior literature documents that patents as a measure of innovation performance lead to higher firm performance (e.g., Gu 2005; Hirshleifer et al. 2013), but it has not yet examined the relation between capitalized R&D and patents. If R&D capitalization reflects managers' private information on the expected success of R&D, then the capitalized portion of R&D will represent a leading indicator of innovation performance. Given that patents as a measure of innovation performance are positively associated with future firm performance,[8] R&D capitalization will be associated with future firm performance if it is positively associated with innovation performance.

However, R&D investments are inherently uncertain (Kothari et al. 2002; Thomas et al. 2010) and managers may be unable to reliably estimate an R&D project's success potential. Additionally, the criteria for R&D capitalization under IAS 38 entail significant management discretion and provide the opportunity for managers to opportunistically capitalize R&D to manage earnings (Kreß et al. 2019; Mazzi et al. 2019). If this is indeed the case, capitalized R&D will not be related to future innovation performance. Consistent with the standard setter's intention, we test whether R&D capitalization reveals managements' private information about the prospects of R&D activities and hence represents a leading indicator of innovation performance. We hypothesize[9]:

H1: *The rate of R&D capitalization is positively related to future innovation performance.*

H1 investigates the rate of capitalized R&D rather than the level of capitalized amounts since high capitalized amounts could be the result of high R&D investments and low success potential, or the result of low R&D investments and high success potential. Following the proposition that larger firms have comparative advantages in generating benefits from R&D investments (Schumpeter 1942), a large body of literature has examined R&D scale effects based on the inherent link between R&D investment scale and firm size. While patent-based innovation output relative to R&D investments is generally higher for smaller firms (e.g., Cohen and Klepper 1996; Jensen and Webster 2006), prior literature also documents that larger firms benefit from spillover and cost-spreading effects (Henderson and Cockburn 1996) and systematically higher future economic benefits related to

[8] We verify this result of prior research for our sample in additional analyses (Sect. 5).

[9] We investigate the rate of capitalized R&D rather than the level of capitalized amounts because high R&D capitalization amounts could be the result of high R&D investments with low success potential, or the result of low R&D investments with high success potential.

R&D investments (Ciftci and Cready 2011). These studies rely on firm size to examine the marginal productivity of R&D. However, firms with similar sizes may vary with respect to R&D intensity, i.e., relative R&D spending. We thus directly examine how the level of capitalized R&D is related to future benefits and test the moderating effect of R&D intensity.

Prior literature finds that R&D intensity positively affects future earnings (Ciftci and Cready 2011), excess stock returns, and their persistence (e.g., Anagnostopoulou and Levis 2008; Asthana and Zhang 2006). Consistent with these results and prior literature on R&D scale effects (e.g., Ciftci and Cready 2011; Cohen and Klepper 1996; Henderson and Cockburn 1996), we propose that R&D intensity moderates the relation between the R&D capitalization rate and future innovation performance. All else equal, a firm with low relative R&D spending and a high capitalization rate is likely to achieve lower innovation performance and generate smaller benefits for investors than a firm with high relative R&D spending, e.g., because firms with high relative R&D spending benefit from spillover effects. Consequently, we expect that R&D capitalization is more strongly associated with future innovation performance when R&D intensity is high. This also implies that the level of R&D capitalization as the product of the R&D capitalization rate and R&D expenditures is positively associated with future innovation. We hypothesize:

H2: *The positive association of the rate of R&D capitalization and future innovation performance is positively moderated by R&D intensity.*

Above, we hypothesize that R&D capitalization can reveal managers' private information and signal the prospects of R&D activities. However, since R&D capitalization involves managerial discretion, it provides the opportunity to manage earnings. Managers may opportunistically capitalize R&D expenditures to achieve short-term earnings targets, as documented in prior studies (e.g., Markarian et al. 2008). Also, managers may prefer not to capitalize R&D expenditures to avoid disclosing proprietary information to their competitors (Graham et al. 2005; Jones 2007). Consequently, capitalized R&D may not be related to expected future benefits of the project due to the managements' opportunistic use of accounting discretion.

Managers can expect sanctions for unjustified capitalization when impairments in later periods reveal prior earnings management (Knauer and Wöhrmann 2016).[10] These negative consequences to unjustified R&D capitalization encourage truthful reports about expected R&D success. Consequently, unjustified R&D capitalization is more likely to occur when managers have incentives to manage earnings. Prior literature has identified three common earnings targets that are related to accruals-based earnings management (e.g., Dinh et al. 2016; García Osma and Young, 2009): managers aim to report earnings above zero, previous year's earnings (Burgstahler and Dichev 1997), and analysts' forecasted earnings (Dechow and Skinner 2000). When current earnings are below one of these earnings targets, managers have incentives to exploit their discretion in R&D capitalization to increase earnings (Dechow and Skinner 2000). We thus expect that capitalized R&D is only related

[10] Detecting earnings management with respect to R&D capitalization is difficult since R&D investments are inherently uncertain and R&D projects may fail in periods after capitalization despite managers having reasonably expected project success. Prior literature finds that managers are sometimes unable to correctly predict R&D success (Cazavan-Jeny et al. 2011) such that impairment of R&D capitalization is not necessarily due to false signals in the past (Dinh et al. 2016).

to future innovation performance in the absence of earnings management motives and hypothesize:

H3 *The association of the rate of R&D capitalization and future innovation performance is present only for firms not suspect of earnings management.*

4 Research design

4.1 Measurement of innovation performance

Prior studies on R&D capitalization in national settings have used sales growth (Cazavan-Jeny et al. 2011) and future earnings (Ahmed and Falk 2009; Lev and Sougiannis 1996) to examine whether R&D capitalization provides information about future benefits. Earnings capture economic benefits from R&D activities (Laursen and Salter 2006), but they are a lagging proxy of innovation success (Mankin 2007) that is also subject to numerous other factors (Jaffe 1989), including accounting choices, and managerial incentives. Especially in industries with long innovation cycles (e.g., pharmaceuticals; Gu 2005), confounding factors influence lagging proxies over time. It is thus difficult to empirically capture a relationship between R&D capitalization and future earnings. We use earnings to analyze the informativeness of capitalized R&D in additional analyses only. In our main analyses, we use two more direct measures of innovation performance following prior management literature (Acs et al. 2002; Goldman et al. 2020) to address concerns related to reporting incentives that may simultaneously affect R&D capitalization and other accounting choices: (1) patent applications and (2) patent citations. We use patent applications to measure the quantity of a firm's innovation performance because patent applications are closely related to the period of innovation. Since patent applications are costly, they reflect a firm's expected innovation success (Archibugi 1992) and indicate valuable innovation with high probability of (commercial) success.[11]

In addition to patent applications, we use patent citations to measure the quality of innovation performance. Following Ciftci and Zhou (2016), we use patent citations received in the first five years after patent publication.[12] Since the probability of patent citations increases over time (van Zeebroeck 2011), we ensure that the sample period spans at least five years after patent publication (Hall et al. 2002) such that recent patents do not suffer from truncation effects. Patent citations also depend on the patent's industry sector and technology field (Hall et al. 2002). To account for these differences, we follow prior research and weight patent citations with the average citation for patents from the same year and industry in our sample (e.g., Gu 2005; Pandit et al. 2011).

[11] One of the three patent criteria of the European Patent Office and the German Patent Office explicitly requires that industrial application of the invention is likely (§1 German Patent Code; §52 European Patent Convention). Similarly, capitalization of an R&D investment under IAS 38 requires a high probability of success. Capitalization is compulsory in the case of technical and commercial feasibility of the asset.

[12] The 5-year-period is also consistent with the finding that R&D expenditures influence future earnings for approximately 5 years (Lev and Sougiannis 1996).

4.2 Capitalization and innovation performance

We analyze the relation between a firm's R&D capitalization rate in t = 0 and future innovation performance (H1) based on the following equation:

$$\begin{aligned}\text{InnoPerf}_{i,t+1+m} = \beta_0 + \beta_1\text{CAPRate}_{i,t} + \beta_2\text{RDint}'_{i,t} + \beta_3\text{CAPRate}_{i,t} * RD\text{int}'_{i,t} \\ + \beta_4\text{CROSS}_{i,t} + \beta_5\text{BOARDInd}_{i,t} + \beta_6\text{MB}_{i,t} + \beta_7\text{SIZE}_{i,t} \\ + \beta_8\text{AGE}_{i,t} + \beta_9\text{LEV}_{i,t} + \beta_{10}\text{PROF}_{i,t} + \text{IND} + \text{YEAR} + \varepsilon_{i,t}\end{aligned} \quad (1)$$

Innovation performance $InnoPerf_{i,t+1+m}$ is a firm's success in producing innovative outcomes in year t + 1, observable m years later. In Eq. (1), we use two different measures for *InnoPerf*: the number of patent applications[13] per million EUR of adjusted total assets (*PA*) as a proxy for quantitative *InnoPerf* and patent citations per million EUR of adjusted total assets (*PC*) as a qualitative measure of *InnoPerf*.[14] Since patenting activities are only observable in later periods, we introduce a time lag m, where m represents the time between innovation performance in t + 1 and the period when future innovation performance becomes observable in t + 1 + m. Since patent applications will only be reported 18 months after application (e.g., §31 German Patent Code; §93 European Patent Convention; 35 U.S. Code §122), we use a time lag of 1.5 years (m = 1.5) for *PA*. A patent can only be cited after publication. Consequently, patent citations received in the first five years can be observed 6.5 years after patent application (m = 6.5). To measure *InnoPerf* in t = 1 based on the number of patent citations, we use patent citations in t + 7.5 years ($PC_{t+7.5}$).

The R&D capitalization rate $CAPRate_{i,t}$ is the rate of total R&D expenditures (expensed R&D + capitalized R&D) that is capitalized by firm i in year t and reflects the share of R&D investments with a high probability of success. A firm's R&D intensity in year t $RDint_{i,t}$ is total R&D expenditures divided by sales and reflects the firm's financial involvement in R&D. The interaction term $CAPRate_{i,t} * RDint_{i,t}$ is the level of R&D capitalization and captures potential moderating effects of R&D intensity on the relation between the R&D capitalization rate and innovation performance. Following Hayes (2013), we center *RDint* at its mean to ease the interpretation of $\beta_1 (RDint'_{i,t} = RDint_{i,t} - meanRDint_{i,t})$[15]

We control for a firm's cross listing, board independence, market-to-book-ratio, size, age, leverage, and profitability consistent with prior research on the factors that influence firms' R&D capitalization and the transformation of R&D input into R&D output (e.g., Chauvin and Hirschey 1993; Ely et al. 2003; Hirschey and Spencer 1992). $CROSS_{i,t}$ is the number of countries firm i's stock is listed in in year t. $BOARDInd_{i,t}$ equals 0/1/2 if firm i's former CEO is not a member of firm i's supervisory board/is a member of firm i's supervisory board/is the chairman of firm i's supervisory board in year t. $MB_{i,t}$ is a firm's market-to-book equity ratio in year t. $SIZE_{i,t}$ is the natural logarithm of a firm's total assets in year t. $AGE_{i,t}$ is the natural logarithm of firm i's age in year t. $LEV_{i,t}$ is firm i's debt divided by total assets, and $PROF_{i,t}$ is firm i's return on assets in year t. Prior research finds that *CROSS* is negatively related to information asymmetry (e.g., Hope 2003; Lang et al. 2003),

[13] Every invention (patent family) is counted only once irrespective of the number of patent applications for a specific invention at different patent offices,

[14] All patent measures (patent applications and patent citations) are deflated by the firm's adjusted total assets.

[15] This transformation does not affect the size and significance of β2 to β8 (Hayes 2013).

we hence expect capitalized R&D to be more informative for cross listed firms. *BOARDInd* captures whether the supervisory board can mitigate earnings management (e.g., Amran et al. 2009; Chen and Roberts 2010), and we expect capitalized R&D to be more informative when the previous CEO is not a member of the supervisory board. We control for *CROSS* and *BOARDInd* to capture agency conflicts that influence firms' discretionary R&D capitalization decisions, but we do not predict a directional effect on *InnoPerf*. *MB* captures growth opportunities and market expectations (Tidd et al. 1996; Gross et al. 2024); we hence expect a positive effect. Evidence on the effect of *SIZE* is mixed: prior research documents positive (e.g., Chauvin and Hirschey 1993; Scherer 1965) and negative (Cohen and Klepper 1996; Hirschey and Spencer 1992) effects on innovative activities. We thus do not predict a directional effect of *SIZE*. Mature firms typically have larger patent portfolios since they have had more time to innovate, and R&D projects may be further along in the process to patent application (Ely et al. 2003; Hand 2001). Conversely, Brancati (2015) documents that younger firms are more innovative, hence we do not predict a directional effect of *AGE*. Consistent with Xin et al. (2019), we expect a negative effect of *LEV*, since debt financing requires firms to reveal proprietary information on innovative activities. *PROF* captures firms' previous and current innovation performance and controls for firms' capability to internally fund R&D projects (Brancati 2015). We thus expect a positive effect of *PROF* on innovation performance. Equation (1) further includes industry (*IND*) and year (*YEAR*) fixed effects. Consistent with prior literature, the book value of assets and the book value of equity are adjusted to values before R&D capitalization. We use panel data in all regression analyses to account for potential unobserved heterogeneity and report robust standard errors to mitigate potential heteroscedasticity.

First, we test Eq. (1) based on an OLS regression model with robust standard errors and industry and year fixed effects to explore the effect of *CAPRate* at the mean of *RDint*. Additionally, we also apply the Johnson-Neyman technique to test for which values of the moderator *RDint* an insignificant conditional effect of *CAPRate* on *InnoPerf* becomes significant or vice versa (Hayes 2013; Preacher et al. 2006). These transition points define regions of *RDint* for which the effect of *CAPRate* on *InnoPerf* is significantly different from zero.

Second, to safeguard against omitted variables and the correlation of *CAPRate* with the error term, we instrument *CAPRate* and apply a 2SLS approach. Following prior literature, we use the lagged share of capitalized R&D (*LagCAPRate*), *CROSS* and *BOARDInd* as instrumental variables (IV) (e.g., Dinh et al. 2016; Dinh & Schultze 2022; Markarian et al. 2008) in the first stage of our main model:

$$\begin{aligned} \mathrm{CAPRate}_{\mathrm{i,t}} = {} & \beta_0 + \beta_1 RDint'_{\mathrm{i,t}} + \beta_2 \mathrm{LagCAPRate}_{\mathrm{i,t}} + \beta_3 CROSS_{i,t} + \beta_4 BOARDInd_{i,t} + \beta_5 MB_{i,t} \\ & + \beta_6 SIZE_{i,t} + \beta_7 AGE_{i,t} + \beta_8 LEV_{i,t} + \beta_9 PROF_{i,t} + IND + YEAR + \varepsilon_{i,t} \end{aligned} \tag{2}$$

Consistent IV estimations require relevant and exogenous IVs (Stock and Watson 2019), i.e., *LagCAPRate*, *CROSS*, and *BOARDInd* need to be correlated with *CAPRate*, but not with the second stage error term (Larcker and Rusticus 2010). Following prior research (e.g., Dinh and Schultze 2022; Markarian et al. 2008), *LagCAPRate* is our main instrument, since lagged variables can be considered economically exogenous (Harjoto and Jo 2015; Larcker and Rusticus 2010). R&D capitalization likely follows a continuous pattern over time, such that *LagCAPRate* influences *CAPRate* but not future *InnoPerf*. Cross listing has been shown to affect financial reporting decisions and reduce information asymmetry (e.g., Hope 2003; Lang et al. 2003), since cross listed firms are subject to more vigorous regulatory oversight.

We thus expect *CROSS* to mitigate opportunistic R&D capitalization and propose a negative effect on *CAPRate*. However, while *CROSS* is related to accounting decisions, it is largely independent of (unobserved) effects on innovation processes. We further use *BOARDInd* as a third IV, since prior research argues that board independence can mitigate agency problems such as earnings management (e.g., Amran et al. 2009; Chen and Roberts 2010). *BOARDInd* is higher when the supervisory board is more closely associated with the management team, and we expect that a board is more likely to mitigate (opportunistic) R&D capitalization when it is more independent. Hence, we propose a positive coefficient for *BOARDInd*. Similar to *CROSS*, we argue that while *BOARDInd* affects accounting decisions, it is less likely associated with innovation output. The time lag between current R&D capitalization and future innovation performance also alleviates potential endogeneity concerns.

We use these instruments to run the first stage regressions of our 2SLS model. All control variables of the main model are also included in the first stage. The second stage then uses instrumented *CAPRate* to analyze the relation between a firm's R&D capitalization rate in t = 0 and future innovation performance (H1) based on the following equation:

$$\begin{aligned}\mathrm{InnoPerf}_{\mathrm{i,t+1+m}} = {} & \beta_0 + \beta_1 CAPRate_{i,t}(inst) + \beta_2 RDint'_{\mathrm{i,t}} + \beta_3 CAPRate_{i,t}(inst) * RDint'_{\mathrm{i,t}} \\ & + \beta_4 MB_{i,t} + \beta_5 SIZE_{i,t} + \beta_6 AGE_{i,t} + \beta_7 LEV_{i,t} \\ & + \beta_8 PROF_{i,t} + IND + YEAR + \varepsilon_{i,t}\end{aligned} \tag{3}$$

4.3 Earnings management and innovation performance

We further examine whether the relation between a firm's R&D capitalization rate and future innovation performance is stronger for firms not suspect of earnings management (H3). We follow García Osma and Young (2009), Dinh et al. (2016) and split the sample into two subsamples based on the dummy variable *EMSuspect*, which captures whether a firm is likely to use R&D capitalization to meet earnings targets. Analysts' consensus earnings forecast, prior year's earnings, and the zero line of earnings represent such earnings targets (e.g., Cazavan-Jeny et al. 2011; Dinh et al. 2016). We calculate two adjusted earnings figures if all R&D is (i) expensed, or (ii) capitalized. *EMSuspect* equals 1 if at least one motive for opportunistic R&D capitalization is present, that is, if at least one of the three earnings targets is larger than adjusted earnings assuming full R&D expensing, but smaller than adjusted earnings assuming full capitalization. We split our sample based on *EMSuspect* and reanalyze Eq. (1) for the two subsamples separately. In the robustness checks, we further identify suspect firms based on whether actual capitalization decisions led to achieving earnings targets. The regression coefficients in the two subsamples provide evidence on whether the relation between the current R&D capitalization rate and future innovation performance differs with earnings management incentives.

5 Sample description

We obtain data on patent applications and patent citations from the European Patent Office's Worldwide Patent Statistical Database (PATSTAT). We identify patent applications for our sample firms based on search engine logic.[16] Information on R&D activities

[16] Similar to Von Graevenitz et al. (2013), we used the name of each company as idiosyncratic characteristic and incrementally refined our keyword set.

are hand-collected from firms' annual reports. All other data is obtained from Refinitiv Eikon.

5.1 Sample selection

Our sample comprises all German public firms that were listed in the main stock market indices DAX, MDAX, or TecDAX at least once during the period 2000–2012. We use patent data until 2019, since patent information is observed with a time lag of up to 6.5 years. Firms are categorized in 19 different industries according to the Industry Classification Benchmark (ICB) (super sector level). We exclude the financial sector where R&D investments are of minor importance. The initial sample comprises 2275 firm year observations for 114 unique firms. We exclude 460 firm year observations that are not based on IFRS and 405 inactive firm year observations (e.g., pre-IPO, merger, bankruptcy, delisting). We exclude 592 firm year observations without R&D activities or no information thereon and 120 firm year observations due to missing data. The final sample comprises 698 firm year observations for 114 unique firms.

We create two subsamples based on whether a firm has incentives to use R&D capitalization to meet analysts' consensus earnings forecasts, prior year's earnings, and zero earnings. 409 firm year observations (58.6%) are categorized as non-suspect observations, and 289 firm year observations (41.4%) are categorized as suspect observations. Dinh et al. (2016) categorize 48.4% of capitalizing firms as suspect firms, which is similar to our classification.[17]

5.2 Descriptive statistics

The mean capitalization rate in our sample is 17.7% (Table 1) and ranges from 0% (minimum) to 98% (maximum) of R&D expenditures. *CAPRate* is significantly higher in non-suspect than suspect firms (19.5% vs. 15.2%; $p<0.01$). Mean total R&D expenditures are EUR 349 million and average R&D intensity is 8.3% of sales, which demonstrates that R&D investments are highly relevant in our sample. Mean R&D expenditures (EUR 433 million vs. EUR 289 million; $p<0.05$) and *RDint* (10.4% vs. 6.9%; $p<0.01$) are significantly higher among suspect firms. The sample firms are highly innovative, with an average of 151.7 patent applications per year, and 85.3 patent citations during the first 5 years after patent publication.

Table 2 shows Spearman rank (Bravais-Pearson) correlation coefficients above (below) the diagonal for the main variables. *PA* and *PC* are significantly correlated. We do not find evidence for a uniform relationship between *CAPRate* and *PA* and *PC*, except for a significant Spearman correlation between *CAPRate* and *PC*. Consistent with the notion that *RDint* influences the relation between the R&D capitalization rate and future innovation performance, *RDint* is significantly correlated with *PA* and *PC*, except for the Bravais-Pearson correlation between *RDint* and *PC*. Accordingly, *CAPLevel* is significantly correlated

[17] García Osma and Young (2009) follow a similar approach and examine accruals-based earnings management in a sample of U.K. firms. Based on the incentive to meet or beat prior year earnings or zero earnings, they separately identify 5.9% and 13.1% of firms as suspect based on either measure, but do not include analysts' earnings forecasts. Bushee (1998) focuses on real earnings management by examining whether a firm can meet or beat prior year earnings by cutting R&D and categorizes 17.7% of observations as suspect firms in a U.S. sample.

Table 1 Descriptive statistics for main variables

Variable	N	Mean	Median	Std. Dev	Min	Max	Difference (t-stat.)
PA	698	0.043	0.02	0.08	0.00	0.54	−0.007
Non-suspect firms	409	0.040	0.01	0.08	0.00	0.54	(−1.10)
Suspect firms	289	0.047	0.02	0.07	0.00	0.54	
PC	698	0.025	0.01	0.06	0.00	0.39	−0.004
Non-suspect firms	409	0.024	0.01	0.06	0.00	0.39	(−0.89)
Suspect firms	289	0.027	0.01	0.06	0.00	0.39	
RDeffort	698	349,000 K	39,900 K	939,000 K	18 K	7,200,000 K	−144,000 K
Non-suspect firms	409	289,000 K	31,400 K	849,000 K	18 K	7,200,000 K	(−2.00**)
Suspect firms	289	433,000 K	45,400 K	1,050,000 K	2,988 K	5,930,000 K	
CAPRate	698	0.177	0.09	0.22	0.00	0.98	0.044
Non-suspect firms	409	0.195	0.07	0.25	0.00	0.98	(2.62***)
Suspect firms	289	0.152	0.10	0.17	0.00	0.85	
RDint	698	0.083	0.05	0.15	0.00	1.00	−0.035
Non-suspect firms	409	0.069	0.03	0.13	0.00	1.00	(−3.13***)
Suspect firms	289	0.104	0.06	0.16	0.00	1.00	
CAPLevel	698	0.009	0.00	0.02	0.00	0.18	−0.002
Non-suspect firms	409	0.008	0.00	0.02	0.00	0.18	(−1.36)
Suspect firms	289	0.010	0.00	0.01	0.00	0.08	
MB	698	2.326	1.83	2.07	0.19	26.99	0.281
Non-suspect firms	409	2.442	1.83	2.39	0.19	26.99	(1.77*)
Suspect firms	289	2.161	1.83	1.49	0.25	9.25	
SIZE	698	21.117	20.88	2.12	16.07	26.22	0.346
Non-suspect firms	409	21.260	21.00	2.18	16.07	26.22	(2.13**)
Suspect firms	289	20.914	20.66	2.02	16.64	25.85	
AGE	698	4.098	4.44	0.94	1.39	5.54	−0.024
Non-suspect firms	409	4.089	4.41	0.96	1.39	5.54	(−0.33)
Suspect firms	289	4.111	4.48	0.92	2.08	5.53	
LEV	698	0.574	0.60	0.20	0.05	1.81	0.027
Non-suspect firms	409	0.585	0.61	0.20	0.05	1.81	(1.78*)
Suspect firms	289	0.558	0.59	0.19	0.09	0.90	
PROF	698	0.057	0.07	0.15	−1.24	0.79	0.006
Non-suspect firms	409	0.060	0.07	0.17	−1.24	0.55	(0.50)
Suspect firms	289	0.054	0.06	0.12	−0.49	0.79	
CROSS	698	0.287	0.00	0.95	0.00	9.00	0.017
Non-suspect firms	409	0.293	0.00	0.96	0.00	9.00	(0.23)

Table 1 (continued)

Variable	N	Mean	Median	Std. Dev	Min	Max	Difference (t-stat.)
Suspect firms	289	0.277	0.00	0.94	0.00	9.00	
BOARDIND	698	0.464	0.00	0.72	0.00	2.00	0.054
Non-suspect firms	409	0.487	0.00	0.73	0.00	2.00	(0.97)
Suspect firms	289	0.433	0.00	0.72	0.00	2.00	

This table reports the mean, median, standard deviation, minimum and maximum for our main variables based on a sample of 698 firm year observations of innovation performance obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. This sample is then split into 289 firm year observations suspect of earnings management and 409 firm year observations, that are not suspect of earnings management and descriptive statistics are presented for these subsamples separately. The last column presents the difference and t-statistics for the subsamples. *PA* and *PC* are winsorized at 99% and 1%. Variable definitions can be found in the Appendix

K = 1.000 EUR

***, **, and * Denote significance at the 1%, 5% and 10% levels, respectively. Significance tests are based on a two-tailed test with robust standard errors

with *PA* and *PC*, except for the Spearman correlation between *CAPLevel* and *PC*. The Bravais-Pearson correlation coefficient for *PROF* and *PC* is significant and positive. Since the correlation coefficients are below the critical thresholds, multicollinearity is unlikely to be a problem in our sample. Unless otherwise noted, Variance Inflation Factors (VIFs) are below the conservative threshold value 5 in the analyses, which supports this inference.

6 Regression results

6.1 R&D capitalization and innovation performance

Table 3 presents the results for regressing Eqs. (1)–(3) about the effect of R&D capitalization on future innovation performance measured by patent applications *PA* (panel A) and patent citations *PC* (panel B).[18] Panel A columns (1)–(3) present regression results for testing the unconditional effect of capitalized R&D without considering the influence of R&D intensity. In column (1), the coefficient on *CAPRate* is not significant while *RDint* is significant and positive (0.085, $p<0.05$) in an OLS analysis. In column (3), the coefficients on *CAPRate* (0.050, $p<0.05$) and *RDint* (0.098, $p<0.05$) are both significant and positive in a 2SLS model, consistent with H1. Column (2) presents the first stage results for instrumenting *CAPRate*.

We present our main results from Eq. (1) in column (4) and from Eq. (3) in column (6) to test whether capitalized R&D is positively related to future innovation performance (H1) and whether this association is positively moderated by firms' R&D intensity (H2). The first stage results for the 2SLS model (Eq. 2) are presented in column (5). In both columns

[18] Untabulated analyses for the effect of *RDint* find that the coefficient on *RDint* is significant and positive in the analysis of *PA* (0.075, $p<0.05$ one-tailed), but insignificant in the analysis of *PC*. These results indicate that R&D expenditures are a prerequisite for innovation but provide insufficient information to estimate future innovation success.

Table 2 Correlations of main variables

Variable (N = 703)	$PA_{t+2.5}$	$PC_{t+7.5}$	*CAPRate*	*RDint*	*CAPLevel*	*MB*	*SIZE*	*AGE*	*LEV*	*PROF*	*CROSS*	*BOARDInd*
$PA_{t+2.5}$		0.837*	− 0.042	0.394*	0.153*	0.083*	− 0.331*	0.033	− 0.179*	− 0.046	− 0.200*	0.071
$PC_{t+7.5}$	0.833*		− 0.111*	0.317*	0.056	0.128*	− 0.131*	0.089*	− 0.126*	0.058	− 0.086*	0.101*
CAPRate	0.037	0.021		− 0.143*	0.845*	− 0.060	0.084*	− 0.074	0.302*	− 0.280*	− 0.032	− 0.004
RDint	0.130*	0.062	− 0.178*		0.249*	0.031	− 0.424*	− 0.316*	− 0.417*	− 0.156*	0.020	− 0.080*
CAPLevel	0.356*	0.245*	0.522*	0.097*		− 0.068	− 0.088*	− 0.124*	0.129*	− 0.288*	− 0.033	− 0.024
MB	0.181*	0.199*	− 0.044	− 0.011	0.002		− 0.184*	− 0.214*	− 0.202*	0.479*	0.015	0.001
SIZE	− 0.349*	− 0.251*	0.089*	− 0.363*	− 0.257*	− 0.182*		0.536*	0.565*	− 0.008*	0.341*	0.148*
AGE	− 0.177*	− 0.136*	− 0.146*	− 0.368*	− 0.327*	− 0.164*	0.484*		0.407*	0.070*	0.057	0.055
LEV	− 0.147*	− 0.231*	0.194*	− 0.373*	− 0.067	− 0.147*	0.512*	0.439*		− 0.281*	0.124*	0.003
PROF	− 0.042	0.100*	− 0.109*	− 0.472*	− 0.254*	0.302*	0.127*	0.182*	− 0.172*		− 0.015	0.088*
CROSS	− 0.109*	− 0.078*	0.061	− 0.046	− 0.007	− 0.063	0.411*	0.070	0.171*	− 0.008		0.116*
BOARDInd	0.066	0.040	− 0.009	− 0.108*	− 0.009	0.055	0.182*	0.082	− 0.006	0.133*	0.150*	

This table reports Spearman rank correlations of the main variables above the diagonal and Bravais-Pearson correlation coefficients below the diagonal. Correlations are based on a sample of 698 firm year observations of innovation performance obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. *PA* and *PC* are winsorized at 99% and 1%. Variable definitions can be found in the Appendix

* Denotes significance at the 5% level

Table 3 The association of R&D capitalization with future innovation performance

Column		(1)		(2)		(3)		(4)	
Model		OLS		2SLS		2SLS		OLS	
				First Stage		Second Stage			
Indep. var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat
Panel A Regression results for future patent applications as dependent variable ($PA_{i,t+2.5}$)									
CAPRate	(+)	0.029	1.42					**0.094**	**2.88**$^{###}$
CAPRate(inst)	(+)					**0.050**	**1.99**$^{##}$		
RDint'	(+)	0.085	2.25$^{##}$	0.008	0.23	0.098	2.25$^{##}$	0.089	2.42$^{###}$
*CAPRate*RDint'*	(+)							**1.701**	**3.52**$^{###}$
*CAPRate(inst)*RDint'*	(+)								
CAPLevel	(+)								
CAPLevel(inst)	(+)								
LagCAPLevel(IV)	(+)								
LagCAPRate(IV)	(+)			0.864	33.55$^{###}$				
CROSS(IV)	(?/-)	−0.001	−0.41	−0.001	0.36			−0.001	−0.52
BOARDInd(IV)	(?/+)	0.014	3.87***	−0.008	−1.58			0.011	2.96***
MB	(+)	0.006	2.67$^{###}$	0.002	0.94	0.007	2.46**	0.006	2.52$^{###}$
SIZE	(?)	−0.015	−5.32***	0.001	0.42	−0.014	−5.07***	−0.012	−4.17***
LEV	(-)	0.030	0.69	−0.020	−0.59	0.041	0.86	0.037	0.85
PROF	(+)	−0.016	−0.51	−0.004	-0 07	−0.003	−0.09	0.018	0.67
Constant	(?)	0.320	6.33***	−0.018	−0.33	0.310	5.65***	0.229	4.14***
IND		YES		YES		YES		YES	
YEAR		YES		YES		YES		YES	
N		698		589		589		698	
F statistic		6.48***		384.04***		5.76***		5.57***	

Table 3 (continued)

Column		(1)		(2)		(3)		(4)	
Model		OLS		2SLS		2SLS		OLS	
				First Stage		Second Stage			
Indep. var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat
Adjusted R^2		0.2061		0.7917		0.2022		0.2750	
Highest VIF		1.99						2.11	
Mean VIF		1.58						1.67	
Endogeneity test of endogenous regressor				0.223					
Hansen J statistic (Overidentification test of all instruments)				12.334***					
Kleibergen-Paap Wald F statistic (Weak identification test)				384.035 (> 19.93)					

Column		(5)		(6)		(7)		(8)		(9)	
Model		2SLS		2SLS		OLS		2SLS		2SLS	
		First Stage		Second Stage				First Stage		Second Stage	
Indep. var	Predicted Sign	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat
Panel A Regression results for future patent applications as dependent variable ($PA_{i,t+2.5}$)											
CAPRate	(+)										
CAPRate(inst)	(+)			**0.144**	**3.44###**						
RDint'	(+)	0.001	0.04	0.106	2.43###						
*CAPRate*RDint'*	(+)										
*CAPRate(inst)*RDint'*	(+)			**2.555**	**3.60###**						
CAPLevel	(+)					**1.103**	**2.91###**				
CAPLevel(inst)	(+)									**2.02**	**3.05###**

Table 3 (continued)

Column		(5)		(6)		(7)		(8)		(9)	
Model		2SLS		2SLS		OLS		2SLS		2SLS	
		First Stage		Second Stage				First Stage		Second Stage	
Indep. var	Predicted Sign	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat
LagCAPLevel(IV)	(+)							0.705	$11.81^{\#\#\#}$		
LagCAPRate(IV)	(+)	0.871	$27.88^{\#\#\#}$								
CROSS(IV)	(?/-)	−0.008	$-2.01^{\#\#}$			0.000	0.47	−0.000	−0.98		
BOARDInd(IV)	(?/+)	−0.008	−1.65			0.011	3.08^{***}	0.001	1.39		
MB	(+)	0.002	$1.41^{\#}$	0.006	$2.17^{\#\#}$	0.006	$2.64^{\#\#\#}$	0.000	0.99	0.006	$2.17^{\#\#}$
SIZE	(?)	0.002	0.81	−0.010	-4.22^{***}	−0.013	-4.87^{***}	−0.000	−0.56	−0.012	-4.60^{***}
LEV	(-)	−0.024	−0.68	0.049	1.00	0.028	0.71	−0.001	−1.41	0.046	1.02
PROF	(+)	−0.010	−0.19	0.049	$1.48^{\#}$	−0.038	−1.36	−0.012	−2.23	−0.016	−0.52
Constant	(?)	−0.044	−0.75	0.178	3.94^{***}	0.305	5.84^{***}	0.008	1.24	0.266	5.64^{***}
IND		YES		YES		YES		YES		YES	
YEAR		YES		YES		YES		YES		YES	
N		589		589		698		589		589	
F statistic		204.54^{***}		4.40^{***}		6.17^{***}		56.69^{***}		5.04^{***}	
Adjusted R^2		0.7934		0.2267		0.2342		0.6305		0.1873	
Highest VIF						2.09					
Mean VIF						1.43					
Endogeneity test of endogenous regressor		5.859^{**}						7.726^{*}			
Hansen J statistic (Overidentification test of all instruments)		16.996^{***}						6.096^{**}			
Kleibergen-Paap Wald F statistic (Weak identification test)		41.551 (> 19.93)						56.692 (> 19.93)			

Table 3 (continued)

Column		(1)		(2)		(3)		(4)	
Model		OLS		2SLS First Stage		2SLS Second Stage		OLS	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat
Panel B Regression results for future patent citations as dependent variable ($PC_{i,t+7.5}$)									
CAPRate	(+)	0.020	1.48#					**0.055**	**2.31##**
CAPRate(inst)	(+)					**0.029**	**1.86##**		
RDint'	(+)	0.009	0.74	0.008	0.23	0.011	0.93	0.012	1.00
*CAPRate*RDint'*	(+)							**0.911**	**2.44###**
*CAPRate(inst)*RDint'*	(+)								
CAPLevel	(+)								
CAPLevel(inst)	(+)								
LagCAPLevel(IV)	(+)								
LagCAPRate(IV)	(+)			0.864	33.55###				
CROSS(IV)	(?/-)	−0.002	−1.59	−0.001	0.36			−0.002	−1.71*
BOARDInd(IV)	(?/+)	0.004	1.88*	−0.008	−1.58			0.003	1.14
MB	(+)	0.004	2.86###	0.002	0.94	0.005	2.81###	0.004	2.63###
SIZE	(?)	−0.005	−4.00***	0.001	0.42	−0.005	−3.61***	−0.003	−2.38**
AGE	(?)	0.005	1.38	0.003	0.53	0.005	1.28	0.007	2.41**
LEV	(-)	−0.051	−2.74###	−0.020	−0.59	−0.053	−2.80###	−0.047	−2.61###
PROF	(+)	−0.006	−0.36	−0.004	−0.07	0.004	0.25	0.012	0.67
Constant	(?)	0.120	4.92***	−0.018	−0.33	0.104	3.74***	0.061	2.07**
IND		YES		YES		YES		YES	
YEAR		YES		YES		YES		YES	
N		698		589		589		698	
F statistic		3.87***		384.04***		3.41***		3.56***	

Table 3 (continued)

Column		(1)		(2)		(3)		(4)	
Model		OLS		2SLS First Stage		2SLS Second Stage		OLS	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat
Adjusted R^2		0.1544		0.7917		0.1671		0.1985	
Highest VIF		1.99			2.11			2.09	
Mean VIF		1.58			1.67			1.43	
Endogeneity test of endogenous regressor				0.102					
Hansen J statistic (Overidentification test of all instruments)				6.237**					
Kleibergen-Paap Wald F statistic (Weak identification test)				384.035 (> 19.93)					

Column		(5)		(6)		(7)		(8)		(9)	
Model		2SLS first stage		2SLS second stage		OLS		2SLS first stage		2SLS second stage	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat
Panel B Regression results for future patent citations as dependent variable ($PC_{i,t+7.5}$)											
CAPRate	(+)										
CAPRate(inst)	(+)			**0.063**	**2.40**$^{\#\#\#}$						
RDint'	(+)	0.001	0.04	0.015	1.21						
*CAPRate*RDint'*	(+)										
*CAPRate(inst)*RDint'*	(+)			**0.936**	**2.35**$^{\#\#\#}$						
CAPLevel	(+)					**0.543**	**1.91**$^{\#\#}$				
CAPLevel(inst)	(+)									**0.710**	**1.71**$^{\#\#}$
LagCAPLevel(IV)	(+)							0.705	11.81$^{\#\#\#}$		
LagCAPRate(IV)	(+)	0.871	27.88$^{\#\#\#}$								
CROSS(IV)	(?/-)	−0.008	−2.01$^{\#\#}$			−0.001	−1.15	−0.000	−0.98		

Table 3 (continued)

Column		(5)		(6)		(7)		(8)		(9)	
Model		2SLS first stage		2SLS second stage		OLS		2SLS first stage		2SLS second stage	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat
BOARDInd(IV)	(?/+)	−0.008	−1.65			0.003	1.28	0.001	1.39		
MB	(+)	0.002	$1.41^{\#}$	0.005	$2.56^{\#\#\#}$	0.004	$2.73^{\#\#\#}$	0.000	0.99	0.005	$2.54^{\#\#\#}$
SIZE	(?)	0.002	0.81	−0.003	-2.39^{**}	−0.004	-3.02^{***}	−0.000	−0.56	−0.004	-2.50^{**}
AGE	(?)	0.004	0.61	0.008	2.27^{**}	0.004	1.27	0.000	0.33	0.004	1.12
LEV	(-)	−0.024	−0.68	−0.050	$-2.63^{\#\#\#}$	−0.044	$-2.61^{\#\#\#}$	−0.001	$-1.41^{\#}$	−0.045	$-2.55^{\#\#\#}$
PROF	(+)	−0.010	−0.19	0.024	1.11	−0.003	−0.21	−0.012	−2.23	0.009	0.46
Constant	(?)	−0.044	−0.75	0.056	1.97^{**}	0.104	4.25^{***}	0.008	1.24	0.084	2.99^{***}
IND		YES		YES		YES		YES		YES	
YEAR		YES		YES		YES		YES		YES	
N		589		589		698		589		589	
F statistic		204.54^{***}		3.20^{***}		4.05^{***}		56.69^{***}		3.52^{***}	
Adjusted R^2		0.7934		0.1815		0.1723		0.6305		0.1585	
Highest VIF											
Mean VIF											
Endogeneity test of endogenous regressor		1.886						6.931^{***}			
Hansen J statistic (Overidentification test of all instruments)		10.637^{**}						2.775			
Kleibergen-Paap Wald F statistic (Weak identification test)		41.551 (> 19.93)						56.692 (> 19.93)			

Table 3 (continued)

Panel C Results of the Johnson-Neyman Technique for significant conditional effects of RDint on future innovation performance

Dependent variable		
Patent applications $PA_{i,t+2.5}$	0.015	Equal to or below this level of RDint
	0.046	Equal to or above this level of RDint
Patent citations $PC_{i,t+7.5}$	0.001	Equal to or below this level of RDint
	0.045	Equal to or above this level of RDint

Panel A of this table presents results from estimating regression Eqs. (1), (2), and (3) examining the relation between the rate of R&D capitalization in t ($CAPRate_{i,t}$), R&D intensity in t ($RDint'_{i,t}$) and patent applications in t + 1 ($PA_{i,t+2.5}$) in columns (1) to (6), and regression analyses of the relation between the level of R&D capitalization in t ($CAPLevel_{i,t}$) and patent applications in t + 1 ($PA_{i,t+2.5}$) in columns (7) to (9) based on a sample of 698 firm year observations of innovation performance obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The models in columns (1), (4), and (7) are run as pooled OLS regressions. To address endogeneity concerns, columns (2) and (3), (5) and (6), and (8) and (9) present the first stage and second stage coefficient of 2SLS regressions of the models in columns (1), (4), and (7). The bottom rows report the number of observations, F-Statistic, Adjusted R^2, highest VIF, mean VIF, and test statistics for the instrumental regressions in columns (2) and (3), (5) and (6), and (8) and (9)

Panel B of this table presents results from estimating regression Eqs. (1), (2), and (3) examining the relation between the rate of R&D capitalization in t ($CAPRate_{i,t}$), R&D intensity in t ($RDint'_{i,t}$) and patent citations in t + 1 ($PC_{i,t+7.5}$) in columns (1) to (6), and regression analyses of the relation between the level of R&D capitalization in t ($CAPLevel_{i,t}$) and patent citations in t + 1 ($PC_{i,t+7.5}$) in columns (7) to (9) based on a sample of 698 firm year observations of innovation performance obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The models in columns (1), (4), and (7) are run as pooled OLS regressions. To address endogeneity concerns, columns (2) and (3), (5) and (6), and (8) and (9) present the first stage and second stage coefficient of 2SLS regressions of the models in columns (1), (4), and (7). The bottom rows report the number of observations, F-Statistic, Adjusted R^2, highest VIF, mean VIF, and test statistics for the instrumental regressions in columns (2) and (3), (5) and (6), and (8) and (9)

Panel C of this table presents the results of the Johnson-Neyman Technique for the analysis of the relation between the rate of R&D capitalization in t ($CAPRate_{i,t}$) and patent applications in t + 1 ($PA_{i,t+2.5}$) (Panel A column 4), and the rate of R&D capitalization in t ($CAPRate_{i,t}$) and patent citations in t + 1 ($PC_{i,t+7.5}$) (Panel B column 4) to identify values of the moderator $RDint_{i,t}$ where the effect of $CAPRate_{i,t}$ on patent applications in t + 1 ($PA_{i,t+2.5}$) and patent citations in t + 1 ($PC_{i,t+7.5}$) is significantly different from zero

PA and *PC* are winsorized at 99% and 1%. Variable definitions can be found in the Appendix

***, **, and * (###, ##, #) Denote significance at the 1%, 5% and 10% levels, respectively. Significance tests are based on a two-tailed (one-tailed) test with robust standard errors

(4) and (6), the coefficients on *CAPRate* (0.094; $p < 0.01$) and *CAPRate(inst)* (0.144; $p < 0.01$) are highly positively significant, in support of H1. Also, the coefficients on the interaction *CAPRate*RDint* (1.701; $p < 0.01$) and *CAPRate(inst)*RDint* (2.555; $p < 0.01$) are significantly positive, which supports H2 and indicates that R&D capitalization of firms with greater R&D activities is more strongly associated with future innovation performance. In the presence of a significant interaction, regression estimates of a conditional regression including the interaction effect are more meaningful than regression estimates of an unconditional regression (Hayes 2013, pp. 319). We hence focus on the contingent effect of the rate of R&D capitalization on future innovation performance presented in columns (4) and (6) to evaluate H1 and H2.

Since *RDint* is mean-centered, the coefficient on *CAPRate* reflects the conditional effect of *CAPRate* on *PA* when *RDint* is at the sample mean (0.083) and indicates that *CAPRate* is positively related to future innovation performance for the average firm. The conditional effect of *RDint* on *PA* is significantly positive (0.089, $p < 0.01$). Based on the average capitalization rate of 0.177, an increase of *RDint* by one percentage point, is related to 0.391 more patent applications per million total assets (assuming that *CAPRate* is constant, such that additional R&D investments have identical success potential as existing R&D investments). Significant control variables carry the expected signs. Results in the 2SLS regression model following Eq. (3) are qualitatively equivalent to the OLS regression results and H1 and H2.

Columns (7)–(9) in panel A present the results for the effect of *CAPLevel* on *PA*. Consistent with H1 and H2, the coefficient on *CAPLevel* (1.103, $p < 0.01$) is significant and positive in column (7). To address endogeneity concerns, we estimate a 2SLS regression model, where we use the lagged capitalization level (*LagCAPLevel*) instead of *LagCAPRate* as the main instrument in the first stage. First (second) stage results are presented in column (8) (column (9)). The results are qualitatively equivalent to the OLS regression results and *CAPLevel(inst)* (2.02, $p < 0.01$) is significantly positively associated with *PA* in column (9).

Table 3 panel B presents results for regression analyses of the association of R&D capitalization and future innovation performance measured by patent citations *PC*. Columns (1)–(3) present regression results for testing the unconditional effect of capitalized R&D. The coefficient on *CAPRate* in column (1) is weakly significant and positive (0.020, $p < 0.10$). The unconditional effect of *CAPRate* in the 2SLS model presented in column (3) is significant and positive (0.029, $p < 0.05$). In columns (4) and (6), we find a significantly positive coefficient on *CAPRate* (0.055, $p < 0.05$) and *CAPRate(inst)* (0.063, $p < 0.01$). Given the average *CAPRate* of 0.177, an increase of *RDint* by one percentage point is related to a 0.173 increase of the number of patent citations per million of adjusted total assets for firms with an average R&D capitalization rate. In columns (7) and (9), we find a significant positive effect of *CAPLevel* (0.543, $p < 0.05$) and *CAPLevel(inst)* (0.710, $p < 0.05$). Overall, the results for *PC* are qualitatively equivalent to the results for *PA* and support H1 and H2.

Table 3 panel C presents the results of the Johnson-Neyman Technique. For *PA*, there are two transition points of *RDint* at which an insignificant (significant) overall effect of *CAPRate* on future *PA*, conditional on levels of *RDint*, turns significant (insignificant) (0.015 and 0.046, $p < 0.10$). When *RDint* is smaller (higher) than or equal to 0.015 (0.046), the conditional effect of *CAPRate* on *PA* is significantly negative (positive), while there is no significant conditional effect of *CAPRate* on *PA* when *RDint* is between 0.015 and 0.046. In our sample, firms with *RDint* below 0.015 (e.g., Lufthansa, Deutsche Telekom, and RWE) primarily engage in software development projects.

These typically do not result in patent applications, which may explain the negative effect of *CAPRate* on *PA*. In our sample, the conditional effect of *CAPRate* on *PA* is significantly positive for 433 firm year observations compared with 158 observations with a significantly negative conditional effect. This suggests that *CAPRate* generally serves as a positive leading indicator for future quantitative innovation performance in industries with higher R&D intensity. For *PC*, the Johnson-Neyman Technique identifies two transition points of *RDint* at 0.001 and 0.045 ($p < 0.10$) for the effect of *CAPRate*. Consistent with the results for *PA*, the conditional effect of *CAPRate* on *PC* is significantly positive for *RDint* above 0.045, and significantly negative below 0.001, while there is no significant conditional effect when *RDint* is above 0.001 but below 0.045.

6.2 R&D capitalization and earnings management

To examine whether the relation between a firm's R&D capitalization rate and future innovation depends on earnings management incentives (H3), we analyze the effect of *CAPRate* on *PA* and *PC* for firms suspect and not suspect of earnings management separately. The sample split is based on the dummy variable *EMSuspect*, which equals 1 if a firm has incentives to use R&D capitalization to meet earnings benchmarks. Table 4 panel A presents regression estimates for the effect of *CAPRate* on *PA* for the two subsamples. Columns (1) and (2) present OLS (Eq. 1), and columns (3)–(6) present the corresponding 2SLS estimates (Eqs. 2 and 3). In columns (1) and (2), we continue to find a significantly positive coefficient on *CAPRate* for non-suspect firms (0.114; $p < 0.01$), whereas there is no significant association for suspect firms. The interaction of *CAPRate* and *RDint* is significantly positive for non-suspect firms (2.021, $p < 0.01$) and only marginally significant for suspect firms (1.216, $p < 0.10$). The 2SLS estimates presented in columns (4) and (6) show equivalent results: we find a significant positive coefficient on *CAPRate* (0.165, $p < 0.01$) and a significant positive interaction effect of *CAPRate* and *RDint* (2.841, $p < 0.01$) for non-suspect firms (column (4)). For suspect firms, the coefficients for *CAPRate* (0.114, $p < 0.10$) and the interaction of *CAPRate* and *RDint* (2.681, $p < 0.10$) are only marginally significant (column (6)). Columns (3) and (5) show the first stage results in the subsamples.

Table 4 panel B presents the results for the two subsamples when using *PC* as the dependent variable. The results are largely equivalent to panel A. OLS results are presented in columns (1) and (2). We find a significantly positive main effect of *CAPRate* (0.071, $p < 0.01$), and a significantly positive interaction effect between *CAPRate* and *RDint* (1.160, $p < 0.01$) for non-suspect firms only. In columns (4) and (6), we find a significantly positive coefficient on instrumented *CAPRate(inst)* (0.081, $p < 0.01$) and a significantly positive interaction effect between *CAPRate* and *RDint* (1.121, $p < 0.05$) for non-suspect firms. In the suspect subsample, only the interaction is marginally significant (0.898, $p < 0.10$). Overall, the results provide consistent support for H3 and indicate that the R&D capitalization rate is only related to future patent applications for firms that are not suspect of earnings management.

In summary, our evidence is consistent with the hypotheses: the R&D capitalization rate is positively related to future innovation performance and this relationship is moderated by R&D intensity. Moreover, we find that the current R&D capitalization rate is related to future innovation performance for firms that are not suspect of earnings

Table 4 The association of R&D capitalization with future innovation performance in suspect and non-suspect firms

Panel A Regression results for future patent applications as dependent variable ($PA_{i,t+2.5}$)

Column		(1)		(2)		(3)		(4)		(5)		(6)	
Model		OLS		OLS		2SLS First Stage		2SLS Second Stage		2SLS First Stage		2SLS Second Stage	
Sample		Non-suspect firms		Suspect firms		Non-suspect firms		Non-suspect firms		Suspect firms		Suspect firms	
		EMSuspect = 0		*EMSuspect = 1*		*EMSuspect = 0*		*EMSuspect = 0*		*EMSuspect = 1*		*EMSuspect = 1*	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	z-stat
CAPRate	(+)	**0.114**	**$2.97^{\#\#\#}$**	**0.043**	**1.17**								
CAPRate(inst)	(+)							**0.165**	**$3.60^{\#\#\#}$**			**0.114**	**$1.52^{\#}$**
RDint'	(+)	0.095	$2.97^{\#\#\#}$	0.076	$1.29^{\#}$	0.016	0.31	0.100	$2.90^{\#\#\#}$	−0.043	−1.42	0.097	$1.51^{\#}$
*CAPRate*RDint'*	(+)	**2.021**	**$4.12^{\#\#\#}$**	**1.216**	**$1.42^{\#}$**								
*CAPRate(inst)*RDint'*	(+)							**2.841**	**$4.07^{\#\#\#}$**			**2.681**	**$1.52^{\#}$**
LagCAPRate(IV)	(+)					0.878	$21.43^{\#\#\#}$			0.844	$18.95^{\#\#\#}$		
CROSS(IV)	(?/-)	−0.001	−0.40	0.001	0.35	−0.008	−1.15			−0.010	$-1.98^{\#\#}$		
BOARDInd(IV)	(?/+)	0.019	3.46^{***}	0.006	1.30	−0.012	−1.60			−0.001	−0.13		
MB	(+)	0.003	$1.31^{\#}$	0.013	$2.29^{\#\#}$	0.003	$1.41^{\#}$	0.003	1.07	−0.000	−0.13	0.015	$2.72^{\#\#\#}$
SIZE	(?)	−0.012	-3.20^{***}	−0.014	-4.77^{***}	0.006	1.39	−0.010	-3.23^{***}	−0.000	−0.06	−0.012	-3.76^{***}
AGE	(?)	0.002	0.42	0.013	1.97^{**}	0.006	0.65	−0.000	−0.06	−0.011	−1.58	0.020	2.31^{**}
LEV	(-)	0.082	1.37	0.007	0.16	−0.025	−0.42	0.096	1.37	−0.027	−0.94	0.018	0.38
PROF	(+)	0.084	$2.88^{\#\#\#}$	−0.075	−1.16	−0.004	−0.05	0.122	$2.78^{\#\#\#}$	−0.023	−0.55	−0.057	−0.98
Constant	(?)	0.254	3.55^{***}	0.249	4.83^{***}	−0.144	−1.60	0.210	3.78^{***}	0.078	1.32	0.152	2.01^{**}
IND		YES		YES		YES		YES		YES		YES	
YEAR		YES		YES		YES		YES		YES		YES	
N		409		289		337		337		252		252	
F statistic		4.05^{***}				130.83^{***}		3.27^{***}		80.79^{***}		16.79^{***}	
Adjusted R^2		0.3814		0.1556		0.7743		0.3154		0.8004		0.1117	
Highest VIF		2.12		2.39									
Mean VIF		1.67		1.80									

Table 4 (continued)

Panel A Regression results for future patent applications as dependent variable ($PA_{i,t+2.5}$)

Column		(1)		(2)		(3)		(4)		(5)		(6)	
Model		OLS		OLS		2SLS First Stage		2SLS Second Stage		2SLS First Stage		2SLS Second Stage	
Sample		Non-suspect firms		Suspect firms		Non-suspect firms		Non-suspect firms		Suspect firms		Suspect firms	
		EMSuspect = 0		*EMSuspect = 1*		*EMSuspect = 0*		*EMSuspect = 0*		*EMSuspect = 1*		*EMSuspect = 1*	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	z-stat
Endogeneity test of endogenous regressor		2.190											
Hansen J statistic (Overidentification test of all instruments)		13.715***											
Kleibergen-Paap Wald F statistic (Weak identification test)		36.021 (> 19.93)											

Panel B Regression results for future patent citations as dependent variable ($PC_{i,t+7.5}$)

Column		(1)		(2)		(3)		(4)		(5)		(6)	
Model		OLS		OLS		2SLS First Stage		2SLS Second Stage		2SLS First Stage		2SLS Second Stage	
Sample		Non-suspect firms		Suspect firms		Non-suspect firms		non-suspect firms		Suspect firms		Suspect firms	
		EMSuspect = 0		*EMSuspect = 1*		*EMSuspect = 0*		*EMSuspect = 0*		*EMSuspect = 1*		*EMSuspect = 1*	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	z-stat
CAPRate	(+)	**0.071**	**2.53###**	**0.013**	**0.55**								
CAPRate(inst)	(+)							**0.081**	**2.36###**			**0.040**	**1.21**
RDint'	(+)	0.032	1.60#	− 0.031	− 1.39	0.016	0.31	0.028	1.53#	− 0.043	− 1.42	− 0.025	− 1.17
*CAPRate*RDint'*	(+)		**2.89###**	**0.432**	**1.16**								

Table 4 (continued)

Panel B Regression results for future patent citations as dependent variable ($PC_{i,t+7.5}$)

Column		(1)		(2)		(3)		(4)		(5)		(6)	
Model		OLS		OLS		2SLS First Stage		2SLS Second Stage		2SLS First Stage		2SLS Second Stage	
Sample		Non-suspect firms		Suspect firms		Non-suspect firms		non-suspect firms		Suspect firms		Suspect firms	
		EMSuspect=0		*EMSuspect=1*		*EMSuspect=0*		*EMSuspect=0*		*EMSuspect=1*		*EMSuspect=1*	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	z-stat
*CAPRate(inst)*RDint'*	(+)	**1.160**						**1.121**	**2.32$^{\#\#}$**			**0.898**	**1.34$^{\#}$**
LagCAPRate(IV)	(+)					0.878	21.43$^{\#\#\#}$			0.844	18.95$^{\#\#\#}$		
CROSS(IV)	(?/-)	−0.002	−1.47	−0.000	−0.00	−0.008	−1.15			−0.010	−1.98$^{\#\#}$		
BOARDInd(IV)	(?/+)	0.008	2.81***	−0.001	−0.25	−0.012	−1.60			−0.001	−0.13		
MB	(+)	0.003	1.70##	0.008	3.47$^{\#\#\#}$	0.003	1.41$^{\#}$	0.004	1.75$^{\#\#}$	−0.000	−0.13	0.008	3.81$^{\#\#\#}$
SIZE	(?)	−0.001	−1.04	−0.007	−2.96***	0.006	1.39	−0.002	−1.04	−0.000	−0.06	−0.005	−2.70***
AGE	(?)	−0.000	−0.04	0.013	2.09**	0.006	0.65	−0.002	−0.55	−0.011	−1.58	0.015	2.39**
LEV	(-)	−0.013	−1.00	−0.066	−1.91$^{\#\#}$	−0.025	−0.42	−0.013	−0.81	−0.027	−0.94	−0.077	−2.37$^{\#\#\#}$
PROF	(+)	0.069	2.91$^{\#\#\#}$	−0.098	−1.75	−0.004	−0.05	0.084	2.74$^{\#\#\#}$	−0.023	−0.55	−0.086	−1.66
Constant	(?)	0.048	1.56	0.125	2.62***	−0.144	−1.60	0.053	1.66**	0.078	1.32	0.070	1.67*
IND		YES		YES		YES		YES		YES		YES	
YEAR		YES		YES		YES		YES		YES		YES	
N		409		289		337		337		252		252	
F statistic		3.00***				130.83***		2.81***		80.79***		6.21***	
Adjusted R^2		0.3049		0.1705		0.7743		0.2532		0.8004		0.1376	
Highest VIF		2.12		2.39									
Mean VIF		1.67		1.80									

Table 4 (continued)

Panel B Regression results for future patent citations as dependent variable ($PC_{i,t+7.5}$)

Column		(1)		(2)		(3)		(4)		(5)		(6)	
Model		OLS		OLS		2SLS First Stage		2SLS Second Stage		2SLS First Stage		2SLS Second Stage	
Sample		Non-suspect firms		Suspect firms		Non-suspect firms		non-suspect firms		Suspect firms		Suspect firms	
		EMSuspect = 0		*EMSuspect = 1*		*EMSuspect = 0*		*EMSuspect = 0*		*EMSuspect = 1*		*EMSuspect = 1*	
Indep.var	Predicted Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	t-stat	Coeff	z-stat
Endogeneity test of endogenous regressor		0.300											
Hansen J statistic (Overidentification test of all instruments)		11.420**											
Kleibergen-Paap Wald F statistic (Weak identification test)		36.021 (> 19.93)											

Panel A of this table presents results from estimating regression Eqs. (1), (2), and (3) examining the relation between the rate of R&D capitalization $CAPRate_{i,t}$ in t and patent applications in t + 1 ($PA_{i,t+2.5}$) based on a sample of 289 firm year observations suspect of earnings management and 409 firm year observations firms, that are not suspect of earnings management. Panel B of this table presents the results of regression Eqs. (1), (2), and (3) examining the relation between the rate of R&D capitalization $CAPRate_{i,t}$ in t and patent citations in t + 1 ($PC_{i,t+7.5}$) based on a sample of 289 firm year observations suspect of earnings management and 409 firm year observations firms, that are not suspect of earnings management

Columns (1), (3) and (4) present regression results for the subsample of firms that are not suspect of earnings management, columns (2), (5), and (6) present regression results for the subsample of firms that are suspect of earnings management. The models in columns (1) and (2) are run as pooled OLS regressions (regression Eq. (1)). To address endogeneity concerns, columns (3) and (4), and (5) and (6) present the first stage (regression Eq. (2)) and second stage (regression Eq. (3)) coefficients of 2SLS regressions of the models in columns (1) and (2). The bottom rows report the number of observations, F-Statistic, Adjusted R2, highest VIF, mean VIF, and test statistics for the instrumental regressions in columns (3) and (4), and (5) and (6)

PA and PC are winsorized at 99% and 1%. Variable definitions can be found in the Appendix

***, **, and * (###, ##, #) Denote significance at the 1%, 5% and 10% levels, respectively. Significance tests are based on a two-tailed (one-tailed) test with robust standard errors

management, but not reliably for suspect firms. These results hold for both our quantitative and qualitative measure of future innovation performance.

7 Additional analyses and robustness

We conduct several sensitivity tests to examine the robustness of our main results. First, we test whether our results are robust to more restrictive procedures for identifying suspect observations. (1) We categorize firm year observations as suspect if hypothetical full expensing leads to adjusted earnings that are smaller than zero, prior year's earnings, or analysts' consensus earnings forecast, but reported earnings are larger than these earnings targets. (2) We further consider whether the R&D capitalization rate is higher than in the previous year. (3) We compare the current capitalization rate to the industry average. Our results are robust to these alternative classification rules, that lead to an increase of non-suspect observations to 89.3%, 93.6%, and 93.0% respectively. Table 5 panel A presents the OLS coefficients and t-statistics for Eq. (1) for *CAPRate* and the interaction between *CAPRate* and *RDint* in the analysis of *PA* in columns (1) and (2), and second stage 2SLS coefficients (Eq. 3) in columns (3) and (4). We consistently find significant and positive coefficients for *CAPRate* and the interaction between *CAPRate* and *RDint* in the non-suspect subsample. Conversely, for suspect firms, the coefficients are not significant with the exception of the interaction between *CAPRate* and *RDint* in the OLS model for classification rule (2) (-2.046, $p<0.1$). Table 5 panel B summarizes the results for the analyses of *PC*. Across all model specifications, we consistently find significant and positive coefficients for *CAPRate* and the interaction between *CAPRate* and *RDint* in the non-suspect subsample, while there are no significant effects in the suspect subsamples.

Second, following prior research (e.g., Gu 2005), we re-estimate Eqs. (1) and (3) for different variants of our dependent variables *PA* and *PC* (untabulated). For *PA*, our inferences remain unaffected when we use longer time lags for innovation performance ($PA_{t+3.5}$, $PA_{t+4.5}$). For *PC*, our results are robust to using longer time lags ($PC_{t+8.5}$, $PC_{t+9.5}$) in the full sample except that we do not find a significant interaction effect of *CAPRate* and *RDint* on $PC_{t+9.5}$ in the 2SLS model. We further use the natural logarithm of *PA* and *PC* instead of deflating patent measures by the firm's adjusted total assets and find that our results for *lnPA* are robust to this alternative variable definition, except that the coefficient on *CAPRate* in the 2SLS analysis of the suspect subsample is insignificant. For *lnPC*, the coefficient on *CAPRate* is not significant in the OLS and 2SLS analyses of the full and the non-suspect sample. Our results for the effect of *CAPLevel* on *PA* and *PC* are also robust to including expensed R&D as an additional control. Untabulated results find that expensed R&D is only significant in the OLS analysis of *PA*.

Since IFRS was voluntary prior to 2005, we also rerun our analyses for the mandatory IFRS period (2005–2012) to address potential self-selection biases. Our main results in the reduced sample (575 firm year observations; 58.4% non-suspect observations) are inferentially equivalent. The results are also robust to winsorizing all variables at the 1st and 99th percentile. We also examine incremental innovation in a change model. Untabulated regression results find a significantly positive relation of changes in *CAPLevel* and *CAPRate* with changes in future *PC*. These results imply that more capitalized R&D leads to more additional future innovation.

Above, we noted that prior research finds a positive association of patents and future performance as a foundation for our hypotheses development (Sect. 3). We verify this

Table 5 Robustness checks of the association of R&D capitalization with future innovation performance with alternative classification procedures of suspect and non-suspect firms

Column	(1)				(2)				(3)				(4)			
Model	OLS				OLS				2SLS second stage				2SLS second stage			
Sample	Non-suspect firms				Suspect firms				Non-suspect firms				Suspect firms			
	EMSuspect = 0				*EMSuspect = 1*				*EMSuspect = 0*				*EMSuspect = 1*			
Indep.var	*CAPRate*		*CAPRate*RDint'*		*CAPRate*		*CAPRate*RDint'*		*CAPRate(inst)*		*CAPRate(inst)*RDint'*		*CAPRate(inst)*		*CAPRate(inst)*RDint'*	
Classification criteria	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	z-stat	Coeff	z-stat	Coeff	z-stat
Panel A Regression results for future patent applications as dependent variable ($PA_{i,t+2.5}$) with alternative classification procedures of suspect and non-suspect firms																
Reported earnings	0.129	3.64###	2.194	4.74###	−0.035	−0.62	−0.729	−0.79	0.192	3.99###	3.333	4.17###	−0.032	−0.62	−0.608	−0.72
Reported earnings and prior year's R&D capitalization rate	0.117	3.37###	2.001	4.24###	−0.100	−1.29	−2.046	−1.75*	0.170	3.72###	2.963	3.95###	−0.098	−1.97	−2.159	−2.79
Reported earnings and industry average R&D capitalization rate	0.128	3.60###	2.179	4.67###	−0.011	−0.12	−0.350	−0.19	0.191	3.97###	3.305	4.14###	−0.043	−0.61	0.259	0.21

Table 5 (continued)

Column	(1)				(2)				(3)				(4)			
Model	OLS				OLS				2SLS second stage				2SLS second stage			
Sample	Non-suspect firms				Suspect firms				Non-suspect firms				Suspect firms			
	EMSuspect=0				*EMSuspect=1*				*EMSuspect=0*				*EMSuspect=1*			
Indep.var	*CAPRate*		*CAPRate*RDint'*		*CAPRate*		*CAPRate*RDint'*		*CAPRate(inst)*		*CAPRate(inst)*RDint'*		*CAPRate(inst)*		*CAPRate(inst)*RDint'*	
Classification criteria	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat	Coeff	z-stat	Coeff	z-stat	Coeff	z-stat
Panel B Regression results for future patent citations as dependent variable ($PC_{i,t+7.5}$) with alternative classification procedures of suspect and non-suspect firms																
Reported earnings	0.074	2.85###	1.198	3.19###	−0.040	−0.83	−0.773	−0.97	0.084	2.76###	1.243	2.78###	−0.028	−0.60	−0.708	−0.97
Reported earnings and prior year's R&D capitalization rate	0.069	2.73###	1.102	2.98###	−0.093	−1.49	−1.850	−2.05	0.077	2.66###	1.152	2.76###	−0.083	−2.08	−1.962	−3.31
Reported earnings and industry average R&D capitalization rate	0.073	2.81###	1.191	3.16###	−0.017	−0.23	0.107	0.07	0.084	2.73###	1.229	2.76###	−0.044	−0.76	0.623	0.57

Panel A of this table summarizes results from estimating regression Eqs. (1) and (3) examining the relation between the rate of R&D capitalization $CAPRate_{i,t}$ and future patent applications ($PA_{i,t+2.5}$) for suspect and non-suspect firm year observations with alternative classification procedures for suspect and non-suspect firm year observations. Panel B of this table presents the results of Eqs. (1) and (3) examining the relation between the rate of R&D capitalization $CAPRate_{i,t}$ and future patent citations ($PC_{i,t+7.5}$) for suspect and non-suspect firm year observations with alternative classification procedures for suspect and non-suspect firm year observations

The classification criteria for splitting 698 firm year observations of innovation performance obtained for IFRS firms listed in the main German stock indices during the period 2000–2012 into a non-suspect and a suspect subsample are whether reported earnings exceed earnings targets while adjusted earnings assuming full expensing of R&D are below earnings targets in the first line, whether reported earnings exceed earnings targets while adjusted earnings assuming full expensing of R&D are below earnings targets and the current rate of R&D capitalization exceeds prior year's rate of R&D capitalization in the second line, and whether reported earnings exceed earnings targets while adjusted earnings assuming full expensing of R&D are below earnings targets and the firm's rate of R&D capitalization exceeds the average rate of R&D capitalization in the firm's industry sector in the third line. Columns (1) and (3) present results for firms that are not suspect of earnings management; columns (2) and (4) present results for firms that are suspect of earnings management. Columns (1) and (2) show regression coefficients and corresponding t-statistics for the rate of R&D capitalization $CAPRate_{i,t}$ and the interaction of the rate of R&D capitalization $CAPRate_{i,t}$ and R&D intensity $RDint'_{i,t}$ obtained in pooled OLS regressions (regression Eq. (1)). To address endogeneity concerns, these models are also run as 2SLS regressions and the corresponding 2nd stage coefficients and z-statistics for the rate of R&D capitalization $CAPRate_{i,t}$ and the interaction of the rate of R&D capitalization $CAPRate_{i,t}$ and R&D intensity $RDint'_{i,t}$ are presented in columns (3) and (4) (regression Eq. (3))

***, **, and * (###, ##, #) Denote significance at the 1%, 5% and 10% levels, respectively. Significance tests are based on a two-tailed (one-tailed) test with robust standard errors

result for our sample and analyze if patent applications and patent citations are indeed positively related to future firm performance. We regress changes in future operating earnings on *PA* and *PC* for years 1–5 (e.g., Gu 2005). *PA* and *PC* in t are significantly positively associated with changes in operating earnings in t + 3, t + 4, and t + 5 (untabulated), which indicates that innovation performance is positively related to future firm performance, consistent with prior research.

Moreover, we follow prior literature and analyze the association of R&D capitalization and future profitability (Dinh and Schultze 2022; Mazzi et al. 2019). We regress current capitalized R&D and current expensed R&D on changes in future operating earnings for years 1 to 5, expecting that current R&D should generate future earnings growth. We control for firm leverage (*LEV*), firm size (*SIZE*), internationalization, and agency conflicts (*CROSS*, *US*, *SUPERVISION*) (Mazzi et al. 2019). Results for the full sample are displayed in Table 6. Panel A presents OLS results. Since capitalized R&D and expensed R&D may be endogenously related, we follow Canace et al. (2018) and estimate a two stage model. We treat current capitalized R&D and current expensed R&D as jointly determined and separately estimate current capitalized R&D and current expensed R&D to derive expected capitalized R&D and expected expensed R&D in the first stage:

$$\begin{aligned} \text{RDcapitalized}_{i,t} = \beta_0 &+ \beta_1\text{RDexpensed}_{i,t} + \beta_2\text{LagRDcapitalized}_{i,t} + \beta_3\text{CROSS}_{i,t} \\ &+ \beta_4\text{BOARDInd}_{i,t} + \beta_5\text{LEV}_{i,t} + \beta_6\text{SIZE}_{i,t} + \beta_7\text{US}_{i,t} \\ &+ \beta_8\text{SUPERVISION}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{4}$$

$$\begin{aligned} \text{RDexpensed}_{i,t} = \beta_0 &+ \beta_1\text{RDcapitalized}_{i,t} + \beta_2\text{LagRDexpensed}_{i,t} + \beta_3\text{CROSS}_{i,t} \\ &+ \beta_4\text{BOARDInd}_{i,t} + \beta_5\text{LEV}_{i,t} + \beta_6\text{SIZE}_{i,t} + \beta_7\text{US}_{i,t} \\ &+ \beta_8\text{SUPERVISION}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{5}$$

Table 6 panel C presents first stage OLS results for instrumenting current capitalized (expensed) R&D based on current expensed (capitalized) R&D, lagged capitalized (expensed) R&D, cross listing, and board independence. In the second stage estimation of changes in future operating earnings, we then use predicted values for current capitalized R&D and current expensed R&D from the first stage:

$$\begin{aligned} \text{earnings change}_{i,t+x} = \beta_0 &+ \beta_1\text{RDcapitalized(inst)}_{i,t} + \beta_2\text{RDexpensed(inst)}_{i,t} + \beta_3\text{LEV}_{i,t} \\ &+ \beta_4\text{SIZE}_{i,t} + \beta_5\text{CROSS}_{i,t} + \beta_6\text{US}_{i,t} + \beta_7\text{SUPERVISION}_{i,t} \\ &+ \varepsilon_{i,t} \quad \text{where} x \in \{1, \dots, 5\} \end{aligned} \tag{6}$$

Table 6 panel B presents the results of the instrumented regression model (6). In panel A, OLS regression estimates show that capitalized R&D in the current year are significantly positively associated with the two- (5.338, $p<0.01$; 2.261, $p<0.05$), three- (5.928, $p<0.05$; 2.945, $p<0.05$), four- (5.068, $p<0.05$; 3.916, $p<0.05$), and 5-year-ahead (8.671, $p<0.05$; 5.182, $p<0.05$) changes in operating earnings (Table 6 panel A). In Panel B, we find that instrumented capitalized R&D is positively associated with the one- (3.064, $p<0.10$), two- (7.616, $p<0.01$), three- (5.569, $p<0.10$), and 4-year-ahead (5.450, $p<0.10$) changes in operating earnings. These findings indicate that capitalized R&D is, on average, associated with future benefits.

In both Panels A and B we also find that expensed R&D is positively associated with changes in future operating earnings for years + 1 to + 5, but with generally smaller

Table 6 The association of R&D capitalization with future changes in operating earnings

Panel A OLS regression results for capitalized R&D and future earnings

Column		(1)		(2)		(3)	
Dep.var		Earnings change in t + 1		Earnings change in t + 2		Earnings change in t + 3	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDcapitalized	(+)	**1.783**	**1.04**	**5.338**	**2.49**$^{\#\#\#}$	**5.928**	**2.31**$^{\#\#}$
RDexpensed	(?)	1.227	1.11	2.261	2.56**	2.945	2.40**
Constant	(?)	0.739	2.11**	0.245	0.51	0.767	0.89
Controls		Included		Included		Included	
N		383		324		267	
F statistic		4.93***		3.50**		1.60	
Adjusted R^2		0.0268		0.0408		0.0761	
Highest VIF		2.77		3.08		3.29	
Column		(4)		(5)			
Dep.var		Earnings change in t + 4		Earnings change in t + 5			
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat		
RDcapitalized	(+)	**5.068**	**1.75**$^{\#\#}$	**8.671**	**2.21**$^{\#\#}$		
RDexpensed	(?)	3.916	2.55**	5.182	2.11**		
Constant	(?)	1.061	0.93	0.579	0.69		
Controls		Included		Included			
N		209		156			
F statistic		1.22		1.11			
Adjusted R^2		0.0934		0.1070			
Highest VIF		3.53		4.05			

Table 6 (continued)

Panel B 2SLS Second Stage Regression results for capitalized R&D and future earnings

Column		(1)		(2)		(3)	
Dep. var		Earnings change in t + 1		Earnings change in t + 2		Earnings change in t + 3	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDcapitalized(inst)	(+)	**3.064**	**1.48#**	**7.616**	**2.77###**	**5.569**	**1.59#**
RDexpensed(inst)	(?)	2.520	1.81*	3.270	2.35**	4.869	2.55**
Contant	(?)	−0.095	−0.26	−0.613	−1.52	−0.131	−0.18
Controls		Included		Included		Included	
N		322		264		206	
F statistic		9.59***		4.69***		1.74	
Adjusted R^2		0.0300		0.0562		0.0883	
Highest VIF		2.55		2.75		2.87	

Column		(4)		(5)	
Dep. var		Earnings change in t + 4		Earnings change in t + 5	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat
RDcapitalized(inst)	(+)	**5.450**	**1.42#**	**3.846**	**0.91**
RDexpensed(inst)	(?)	7.536	2.46**	2.938	1.58
Contant	(?)	0.000	0.00	0.212	0.37
Controls		Included		Included	
N		153		107	
F statistic		1.26		1.67	
Adjusted R^2		0.1363		0.0209	
Highest VIF		2.85		2.90	

Table 6 (continued)

Panel C 2SLS First Stage Regression results for capitalized R&D and future earnings

Column		(1)				(2)				(3)			
Model		Earnings change in t+1				Earnings change in t+2				Earnings change in t+3			
Dep.var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDexpensed	(?)	0.006	0.28			0.022	1.75*			0.028	1.93*		
RDcapitalized	(?)			0.277	1.86*			0.234	2.22**			0.125	0.97
LagRDcapitalized(IV)	(+)	0.954	15.14###			0.995	18.49###			0.960	17.82###		
LagRDexpensed(IV)	(+)			0.846	12.87###			0.832	14.61###			0.829	12.33###
CROSS(IV)	(-/+)	−0.000	−0.66	0.000	0.36	−0.000	−1.07	0.001	0.87	−0.000	−1.04	0.001	1.29#
BOARDInd(IV)	(±)	−0.001	−1.78	0.001	0.39	−0.001	−1.76	0.001	0.44	0.001	−1.31	0.001	0.35
Constant	(?)	0.001	0.10	0.067	2.68***	0.009	1.23	0.076	3.07***	0.008	1.05	0.096	3.27***
Controls		Included		Included		Included		Included		Included		Included	
N		322		322		264		264		206		206	
F statistic		63.48***		115.97***		88.94***		133.52***		61.42***		107.06***	
Adjusted R^2		0.7651		0.8370		0.8444		0.8576		0.8277		0.8509	
Highest VIF		3.08		2.92		3.39		3.29		3.71		3.56	

Column		(4)				(5)			
Model		Earnings change in t+4				Earnings change in t+5			
Dep.var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDexpensed	(?)	0.008	0.84			−0.001	−0.13		
RDcapitalized	(?)			−0.012	−0.10			0.017	0.11
LagRDcapitalized(IV)	(+)	0.957	16.38###			1.021	23.97###		

Table 6 (continued)

Column		(4)				(5)			
Model		Earnings change in t+4				Earnings change in t+5			
Dep.var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
LagRDexpensed(IV)	(+)			0.830	9.39###			0.776	7.61###
CROSS(IV)	(-/+)	−0.000	−0.95	0.001	0.96	−0.001	−2.63#####	0.002	1.26
BOARDInd(IV)	(±)	−0.000	−0.70	0.001	0.77	0.001	1.93##	0.001	0.31
Constant	(?)	0.003	0.55	0.080	2.25**	0.003	0.60	0.116	2.43**
Controls		Included		Included		Included		Included	
N		153		153		107		107	
F statistic		62.32***		101.90***		108.84***		58.85***	
Adjusted R^2		0.8947		0.8908		0.9431		0.8801	
Highest VIF		4.03		3.88		4.53		4.24	

Panel A presents the results of the analysis of the relation between capitalized R&D $RDcapitalized_{i,t}$ and future earnings changes for OLS regression models that control for firm leverage $LEV_{i,t}$, firm size $SIZE_{i,t}$, number of countries the firm is listed in $CROSS_{i,t}$, whether the firm is listed in the United States $US_{i,t}$, and non-executive board oversight $SUPERVISION_{i,t}$. Column (1) shows regression results for 383 firm year observations of 1-year earnings changes obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. Column (2) shows regression results for 324 firm year observations of 2-year earnings changes between t+2 and t; column (3)/(4)/(5) show regression results for 267/209/156 firm year observations of three-/four-/five-year earnings changes between t+3/t+4/t+5 and t. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF

Panel B presents second stage regression results from estimating regression Eq. (6) with instrumented capitalized R&D $RDcapitalized(inst)_{i,t}$ and instrumented expensed R&D $RDexpensed(inst)_{i,t}$. Columns (1)/(2)/(3)/(4)/(5) show coefficients and t-statistics for the second stage regression analyses of 322/264/206/153/107 firm year observations of 1-/2-/3-/4-/5-year earnings changes between t+1/t+2/t+3/t+4/t+5 and t obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF

Panel C presents results for the first stage regressions from estimating regression Eqs. (4) and (5). Columns (1)/(2)/(3)/(4)/(5) show coefficients and t-statistics for the instrumented variables capitalized R&D $RDcapitalized_{i,t}$ and expensed R&D $RDexpensed_{i,t}$ in the analyses of 322/264/206/153/107 firm year observations of 1-/2-/3-/4-/5-year earnings changes between t+1/t+2/t+3/t+4/t+5 and t obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF for the instrumental regressions

***, **, and * (###, ##, #) Denote significance at the 1%, 5% and 10% levels, respectively. Significance tests are based on a two-tailed (one-tailed) test with robust standard errors

Table 7 The association of R&D capitalization with future changes in operating earnings for non-suspect firms

Panel A OLS regression results for capitalized R&D and future earnings for non-suspect firms

Column		(1)		(2)		(3)	
Dep. var		Earnings change in t + 1		Earnings change in t + 2		Earnings change in t + 3	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDcapitalized	(+)	**1.101**	**0.38**	**12.053**	**2.49**$^{\#\#\#}$	**12.720**	**2.50**$^{\#\#\#}$
RDexpensed	(?)	2.653	1.31	3.896	2.33**	3.757	1.86*
Constant	(?)	0.582	1.19	−0.315	−0.58	1.002	0.78
Controls		Included		Included		Included	
N		223		191		157	
F statistic		3.43**		1.61		1.14	
Adjusted R^2		0.0263		0.0770		0.0954	
Highest VIF		2.86		3.17		3.36	

Column		(4)		(5)	
Dep. var		Earnings change in t + 4		Earnings change in t + 5	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat
RDcapitalized	(+)	**10.084**	**1.48**$^{\#}$	**21.159**	**2.32**$^{\#\#}$
RDexpensed	(?)	5.510	2.41**	9.115	1.80*
Constant	(?)	1.877	1.02	0.056	0.04
Controls				Included	
N		123		95	
F statistic		1.22		1.16	
Adjusted R^2		0.1076		0.1235	
Highest VIF		3.71		4.52	

Table 7 (continued)

Panel B 2SLS Second Stage Regression results for capitalized R&D and future earnings for non-suspect firms

Column		(1)		(2)		(3)	
Dep. var		earnings change in t+1		earnings change in t+2		earnings change in t+3	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDcapitalized(inst)	(+)	**3.466**	**0.80**	**16.207**	**2.68**$^{\#\#\#}$	**12.896**	**2.02**$^{\#\#}$
RDexpensed(inst)	(?)	3.922	1.49	4.997	1.92*	5.075	1.81*
Contant	(?)	−0.080	−0.13	−0.926	−1.31	0.615	0.51
Controls		Included		Included		Included	
N		189		157		121	
F statistic		6.17***		2.63**		1.35	
Adjusted R^2		0.0246		0.0914		0.0993	
Highest VIF		2.69		2.98		3.00	

Column		(4)		(5)	
Dep. var		earnings change in t+4		earnings change in t+5	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat
RDcapitalized(inst)	(+)	**12.616**	**1.51**$^{\#}$	**12.011**	**1.05**
RDexpensed(inst)	(?)	9.906	2.54**	2.024	0.41
Contant	(?)	0.238	0.17	0.736	0.62
Controls		Included		Included	
N		90		66	
F statistic		1.17		1.51	
Adjusted R^2		0.1603		0.0024	
Highest VIF		2.96		3.27	

Table 7 (continued)

Panel C 2SLS First Stage Regression results for capitalized R&D and future earnings for non-suspect firms

Column		(1)				(2)				(3)			
Model		Earnings change in t + 1				Earnings change in t + 2				Earnings change in t + 3			
Dep. var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDexpensed	(?)	−0.026	−0.86			0.015	0.78			0.027	1.09		
RDcapitalized	(?)			0.170	1.38			0.135	0.92			0.115	0.60
LagRDcapitalized(IV)	(+)	0.871	8.25###			0.951	11.12###			0.897	10.68###		
LagRDexpensed(IV)	(+)			0.848	8.79###			0.845	12.59###			0.946	11.93###
CROSS(IV)	(-/+)	0.001	1.02	0.000	0.59	−0.000	−0.12	0.001	0.96	−0.000	−0.35	0.001	0.72
BOARDInd(IV)	(±)	−0.001	−1.61	0.001	0.49	−0.002	−1.86	0.000	0.01	−0.001	−1.38	−0.001	0.30
Constant	(?)	0.018	2.02**	0.063	2.54**	0.014	1.83*	0.067	2.83***	0.012	1.76*	0.061	2.17**
Controls		Included		Included		Included		Included		Included		Included	
N		189		189		157		157		121		121	
F statistic		48.54***		68.46***		64.62***		64.07***		57.54***		65.33***	
Adjusted R^2		0.6514		0.8519		0.8136		0.8552		0.7854		0.8532	
Highest VIF		3.17		3.02		3.63		3.51		3.94		3.82	

Column		(4)				(5)			
Model		Earnings change in t + 4				Earnings change in t + 5			
Dep. var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDexpensed	(?)	−0.004	−0.48			−0.002	−0.18		
RDcapitalized	(?)			0.041	0.24			0.018	1.86*
LagRDcapitalized(IV)	(+)	0.874	9.08###			1.034	16.82###		

Table 7 (continued)

Column		(4)				(5)			
Model		Earnings change in t + 4				Earnings change in t + 5			
Dep. var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
LagRDexpensed(IV)	(+)			1.019	$19.93^{\#\#\#}$			1.053	$12.87^{\#\#\#}$
CROSS(IV)	(-/+)	0.000	0.50	0.001	$1.65^{\#}$	−0.000	$-1.54^{\#}$	0.001	0.35
BOARDInd(IV)	(±)	−0.000	−0.74	−0.002	−1.14	0.001	$1.70^{\#\#}$	−0.003	0.41
Constant	(?)	0.010	1.45	0.039	1.74^{*}	0.006	1.11	0.034	2.67^{***}
Controls		Included		Included		Included		Included	
N		90		90		66		66	
F statistic		131.95^{***}		96.95^{***}		89.68^{***}		102.23^{***}	
Adjusted R^2		0.8739		0.9170		0.9592		0.9027	
Highest VIF		4.71		4.64		4.98		4.85	

Panel A presents the results of the analysis of the relation between capitalized R&D $RDcapitalized_{i,t}$ and future earnings changes for OLS regression models that control for firm leverage $LEV_{i,t}$, firm size $SIZE_{i,t}$, number of countries the firm is listed in $CROSS_{i,t}$, whether the firm is listed in the United States $US_{i,t}$, and non-executive board oversight $SUPERVISION_{i,t}$ for non-suspect firms. Column (1) shows regression results for 223 firm year observations of 1-year earnings changes obtained for IFRS firms that are not suspect of earnings management listed in the main German stock indices during the period 2000–2012. Column (2) shows regression results for 191 non-suspect firm year observations of 2-year earnings changes between t + 2 and t; column (3)/(4)/(5) show regression results for 157/123/95 non-suspect firm year observations of three-/four-/five-year earnings changes between t + 3/t + 4/t + 5 and t. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF

To address endogeneity concerns, panel B presents results from estimating regression Eq. (6) for non-suspect firms: the second stage coefficients of a two stage regression of the models in panel A with instrumented capitalized R&D $RDcapitalized(inst)_{i,t}$ and instrumented expensed R&D $RDexpensed(inst)_{i,t}$. Columns (1)/(2)/(3)/(4)/(5) show coefficients and t-statistics for the second stage regression analyses of 189/157/121/90/66 firm year observations of 1-/2-/3-/4-/5-year earnings changes between t + 1/t + 2/t + 3/t + 4/t + 5 and t obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF

Panel C presents results from estimating regression Eqs. (4) and (5) for non-suspect firms. Columns (1)/(2)/(3)/(4)/(5) show coefficients and t-statistics for the instrumented variables capitalized R&D $RDcapitalized_{i,t}$ and expensed R&D $RDexpensed_{i,t}$ in the analyses of 189/157/121/90/66 firm year observations of 1-/2-/3-/4-/5-year earnings changes between t + 1/t + 2/t + 3/t + 4/t + 5 and t obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF for the instrumental regressions

***, **, and * ($^{\#\#\#}$, $^{\#\#}$, $^{\#}$) Denote significance at the 1%, 5% and 10% levels, respectively. Significance tests are based on a two-tailed (one-tailed) test with robust standard errors

Table 8 The association of R&D capitalization with future changes in operating earnings for suspect firms

Panel A OLS regression results for capitalized R&D and future earnings for suspect firms

Column		(1)		(2)		(3)	
Dep. var		Earnings change in t+1		Earnings change in t+2		Earnings change in t+3	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDcapitalized	(+)	**3.975**	**1.51#**	**1.184**	**0.66**	**0.680**	**0.21**
RDexpensed	(?)	−0.152	−0.13	0.855	1.10	1.289	1.52
Constant	(?)	0.379	0.47	0.897	0.83	0.256	0.23
Controls		Included		Included		Included	
N		160		133		110	
F statistic		2.90***		2.99***		2.65**	
Adjusted R^2		0.0170		0.0117		0.0079	
Highest VIF		3.23		3.58		3.77	

Column		(4)		(5)	
Dep. var		Earnings change in t+4		Earnings change in t+5	
Indep. var	Pred. Sign	Coeff	t-stat	Coeff	t-stat
RDcapitalized	(+)	**3.852**	**1.11**	**−2.087**	**−0.76**
RDexpensed	(?)	2.005	2.38**	1.437	1.68*
Constant	(?)	−0.720	−0.87	0.921	1.86*
Controls		Included		Included	
N		86		61	
F statistic		1.63		2.94**	
Adjusted R^2		0.0220		0.0368	
Highest VIF		4.12		4.76	

Table 8 (continued)

Panel B 2SLS Second Stage Regression results for capitalized R&D and future earnings for suspect firms

Column		(1)		(2)		(3)	
Dep.var		Earnings change in t + 1		Earnings change in t + 2		Earnings change in t + 3	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDcapitalized(inst)	(+)	3.900	$1.65^{\#}$	1.441	0.94	0.680	0.20
RDexpensed(inst)	(?)	1.284	1.10	1.394	1.32	3.258	2.40^{**}
Contant	(?)	− 0.630	−0.99	− 0.471	−1.06	− 1.282	-1.95^{*}
Controls		Included		Included		Included	
N		133		107		85	
F statistic		3.10^{***}		5.79^{***}		1.34	
Adjusted R^2		0.0208		0.0221		0.0443	
Highest VIF		2.84		3.00		3.07	

Column		(4)		(5)	
Dep.var		Earnings change in t + 4		Earnings change in t + 5	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat
RDcapitalized(inst)	(+)	4.218	0.96	− 4.306	− 1.10
RDexpensed(inst)	(?)	3.599	1.79^{*}	1.405	0.73
Contant	(?)	− 0.951	− 0.93	0.491	0.65
Controls		Included		Included	
N		63		41	
F statistic		1.17		2.84^{**}	
Adjusted R^2		0.0048		− 0.0266	
Highest VIF		3.69		3.66	

Table 8 (continued)

Panel C 2SLS First Stage Regression results for capitalized R&D and future earnings for suspect firms

Column		(1)				(2)				(3)			
Model		Earnings change in t+1				Earnings change in t+2				Earnings change in t+3			
Dep.var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDexpensed	(?)	0.036	2.51**			0.020	1.56			0.022	1.31		
RDcapitalized	(?)			0.414	1.54			0.320	1.84*			0.173	0.97
LagRDcapitalized(IV)	(+)	1.034	19.83###			1.052	18.24###			1.060	19.88###		
LagRDexpensed(IV)	(+)			0.814	8.76###			0.789	8.71###			0.730	7.53###
CROSS(IV)	(-/+)	−0.001	−3.54###	−0.001	−0.43	−0.001	−3.80###	−0.001	−0.38	−0.001	−4.14###	−0.001	−0.53
BOARDInd(IV)	(±)	−0.000	−0.27	0.001	0.26	0.000	0.37	0.002	0.85	0.001	0.70	0.001	0.48
Constant	(?)	−0.011	−1.34	0.047	0.89	−0.008	−1.00	0.044	1.23	−0.011	−1.34	0.063	1.57
Controls		Included		Included		Included		Included		Included		Included	
N		133		133		107		107		85		85	
F statistic		66.53***		46.11***		54.48***		62.46***		60.16***		66.83***	
Adjusted R^2		0.9217		0.7950		0.9005		0.8361		0.9010		0.8348	
Highest VIF		3.54		3.46		3.96		3.86		4.27		4.14	

Column		(4)				(5)			
Model		Earnings change in t+4				Earnings change in t+5			
Dep.var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
RDexpensed	(?)	0.004	0.20			−0.024	−0.83		
RDcapitalized	(?)			0.122	0.68			0.296	1.40
LagRDcapitalized(IV)	(+)	1.034	15.61###			0.987	14.39###		
LagRDexpensed(IV)	(+)			0.705	5.88###			0.661	6.48###

Table 8 (continued)

Column		(4)				(5)			
Model		Earnings change in t+4				Earnings change in t+5			
Dep.var		*RDcapitalized*		*RDexpensed*		*RDcapitalized*		*RDexpensed*	
Indep.var	Pred. Sign	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
CROSS(IV)	(-/+)	−0.001	−2.58###	−0.002	−1.53	−0.001	−4.01###	−0.001	−0.84
BOARDInd(IV)	(±)	0.001	0.45	0.002	0.70	0.001	0.96	0.004	1.02
Constant	(?)	−0.005	−0.67	0.043	1.12	0.003	0.29	0.061	1.04
Controls		Included		Included		Included		Included	
N		63		63		41		41	
F statistic		52.02***		51.54***		65.56***		45.44***	
Adjusted R^2		0.9091		0.8631		0.9264		0.8918	
Highest VIF		4.43		4.34		5.59		5.57	

Panel A presents the results of the analysis of the relation between capitalized R&D $RDcapitalized_{i,t}$ and future earnings changes for OLS regression models that control for firm leverage $LEV_{i,t}$, firm size $SIZE_{i,t}$, number of countries the firm is listed in $CROSS_{i,t}$, whether the firm is listed in the United States $US_{i,t}$, and non-executive board oversight $SUPERVISION_{i,t}$ for suspect firms. Column (1) shows regression results for 160 firm year observations of 1-year earnings changes obtained for IFRS firms that are suspect of earnings management listed in the main German stock indices during the period 2000–2012. Column (2) shows regression results for 133 suspect firm year observations of 2-year earnings changes between t+2 and t; column (3)/(4)/(5) show regression results for 110/86/61 suspect firm year observations of three-/four-/five-year earnings changes between t+3/t+4/t+5 and t. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF

To address endogeneity concerns, panel B presents results from estimating regression Eq. (6) for suspect firms: the second stage coefficients of a two stage regression of the models in panel A with instrumented capitalized R&D $RDcapitalized(inst)_{i,t}$ and instrumented expensed R&D $RDexpensed(inst)_{i,t}$. Columns (1)/(2)/(3)/(4)/(5) show coefficients and t-statistics for the second stage regression analyses of 133/107/85/63/41 firm year observations of 1-/2-/3-/4-/5-year earnings changes between t+1/t+2/t+3/t+4/t+5 and t obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF

Panel C presents results from estimating regression equation s(4) and (5) for suspect firms. Columns (1)/(2)/(3)/(4)/(5) show coefficients and t-statistics for the instrumented variables capitalized R&D $RDcapitalized_{i,t}$ and expensed R&D $RDexpensed_{i,t}$ in the analyses of 133/107/85/63/41 firm year observations of 1-/2-/3-/4-/5-year earnings changes between t+1/t+2/t+3/t+4/t+5 and t obtained for IFRS firms listed in the main German stock indices during the period 2000–2012. The bottom rows report the number of observations, F-Statistic, Adjusted R^2, and highest VIF for the instrumental regressions

***, **, and * (###, ##, #) Denote significance at the 1%, 5% and 10% levels, respectively. Significance tests are based on a two-tailed (one-tailed) test with robust standard errors

coefficients than capitalized R&D. Whereas the positive association between capitalized R&D and future earnings confirms our expectation that capitalized R&D is informative about future economic benefits, the positive association between expensed R&D and future earnings indicates that a share of expensed R&D still contributes to future earnings. As prior research has shown and as our descriptive statistics indicate, some firms consistently only capitalize very small portions of their R&D, which is often industry specific. For instance, in industries such as pharmaceuticals, R&D projects are often highly uncertain and this uncertainty is only resolved very late in the development process, e.g., after clinical trials. This, in turn, leads to relatively low capitalization and hence large amounts of expensed R&D even though expensed R&D contributes to their future performance. Overall, these results are consistent with prior literature (Dinh and Schultze 2022; Mazzi et al. 2019) and indicate that both capitalized and expensed R&D are associated with future operating earnings, but the association is stronger for capitalized R&D.

When we split the sample and examine non-suspect and suspect firms separately, we find that R&D capitalization is significantly positively associated with future profitability for non-suspect firms in all model specifications, except for the 1-year ahead change in earnings in the OLS and instrumented two stage model, and the five-year ahead change in earnings in the instrumented two stage model (Table 7). Conversely, for suspect firms, capitalized R&D is only weakly significant for the one-year-ahead change in earnings in the OLS (3.975, $p < 0.10$; Table 8 panel A) and instrumented two stage model (3.900, $p < 0.10$; Table 8 panel B). These results are consistent with a positive link between R&D capitalization and future earnings for firms that are not suspect of opportunistic R&D capitalization. Note that for suspect firms, VIFs are above the conservative threshold value 5 (but below 10) in the first stage analyses of 5-year ahead changes in earnings (Table 8 panel C).

8 Conclusion

This paper analyzes the relation between the current R&D capitalization rate and future innovation performance. Whereas prior research has primarily focused on capital market effects, we focus on real economic benefits associated with R&D capitalization and contribute to the question whether R&D capitalization is indicative of future economic benefits. Our study thus also contributes to the continuing quest for a suitable measure of innovation performance in management research. Highly innovative firms offer profitable investment opportunities for investors but evaluating firms' innovation potential is difficult. While timely information on innovation is scarce, R&D capitalization under IFRS may provide information about expected innovation success since development expenditures are capitalized if the firm can demonstrate future commercial and technical feasibility of the R&D investment, and success is highly likely. We use patent applications and patent citations as proxies for firms' quantitative and qualitative innovation performance.

Our results indicate that the current R&D capitalization rate is positively related to future innovation performance for firms not suspect of using R&D capitalization to meet or beat earnings targets. This implies that when firms do not have incentives to manage earnings, the current R&D capitalization rate contains valuable information about the prospects of current R&D projects. Consequently, R&D capitalization is informative for predicting future innovation performance. Our results imply that the rate of R&D capitalization is a leading indicator for future innovation performance and (potential) investors can use capitalized R&D to evaluate a firm's future innovation performance. As such, by allowing firms to capitalize R&D projects with high success potential, standard setters provide market participants with additional information since firms can use R&D capitalization to reveal private information about expected innovation success.

We acknowledge a number of limitations in our study. Our measures of innovation performance, though consistent with prior literature, only reflect a part of all innovation because not all inventions are patentable or patented (Archibugi 1992; Griliches 1990). Since patent applications require disclosure of technology and cause application as well as potential infringement costs, some firms choose secrecy over patents to protect their inventions (Cohen et al. 2000; Hussinger 2006). While some authors consider this a minor limitation (Trajtenberg et al. 1997), new products and new product announcements may be a more comprehensive measure of innovation performance (e.g., Chaney et al. 1991; Pauwels et al. 2004). We encourage future research to extend our study by using alternative measures of innovation performance.

Appendix

See Table 9.

Table 9 Description of variables

Variable	Description (firm *i*, time *t*)
$AGE_{i,t}$	Firm *i*'s age at time *t* measured by the natural logarithm of age in years since founding
$BOARDInd_{i,t}$	Proxy of agency conflict where $BOARDInd_{i,t}$ equals 0/1/2 if the former CEO is not a member of the supervisory board/is a member of the supervisory board/is the chairman of the supervisory board
$CAPLevel_{i,t}$	Firm *i*'s capitalization level at time *t* calculated as capitalized R&D expenditures divided by sales
$CAPRate_{i,t}$	Firm *i*'s capitalization rate at time *t* calculated as capitalized R&D expenditures divided by total R&D expenditures
$CROSS_{i,t}$	Number of countries firm *i*'s stock is listed in at time *t*
$EMSuspect_{i,t}$	Is a dummy variable indicating whether a motive for using R&D capitalization to manage earnings is present in firm *i* at time *t*
$SUPERVISION_{i,t}$	Firm *i*'s board independence at time *t* measured on a four-point scale, where $SUPERVISION_{i,t}$ equals 0/1/2/3 if no/at least 1/3 / ½ / at least ½ of board members are non-executives
IND	Is a vector of dummy variables indicating in which industry the firm was operating in at time *t*
$InnoPerf_{i,t}$	Proxy of future innovation performance for firm *i* at time *t* (*PA* or *PC*)
$LagCAPLevel_{i,t}$	Firm *i*'s lagged capitalization level at time *t* calculated as capitalized R&D expenditures at time *t-1* divided by sales at time *t-1*
$LagCAPRate_{i,t}$	Firm *i*'s lagged capitalization rate at time *t* calculated as capitalized R&D expenditures at time *t-1* divided by total R&D expenditures at time *t-1*
$LagRDcapitalized_{i,t}$	Firm *i*'s lagged total capitalized R&D at time *t* calculated as capitalized R&D at time *t-1* divided by total assets adjusted for R&D capitalization[b] at time *t-2*
$LagRDexpensed_{i,t}$	Firm *i*'s lagged R&D expenses at time *t* calculated as expensed R&D D at time *t-1* divided by total assets adjusted for R&D capitalization[b] at time *t-2*

Table 9 (continued)

Variable	Description (firm i, time t)
$LEV_{i,t}$	Firm i's leverage at time t calculated as (total assets adjusted for R&D capitalization[a] minus book value of equity adjusted for R&D capitalization[b]) divided by total assets adjusted for R&D capitalization[b]
$lnPA_{i,t}$	Natural logarithm of firm i's number of patent applications at time t
$lnPC_{i,t}$	Natural logarithm of firm i's adjusted patent citations at time t received for filed patent applications in the first 5 years
$MB_{i,t}$	Firm i's market-to-book equity ratio at time t, with book value of equity adjusted for R&D capitalization[c]
$PA_{i,t}$	Number of firm i's patent applications at time t, deflated by total assets adjusted for R&D capitalization[b]
$PC_{i,t}$	Firm i's adjusted patent citations at time t received for filed patent applications in the first 5 years, deflated by total assets adjusted for R&D capitalization[b]
$PROF_{i,t}$	Firm i's profitability at time t measured by return on assets[e] calculated as earnings before interest and taxes adjusted for R&D capitalization[a] divided by total assets adjusted for R&D capitalization[b]
$RDcapitalized_{i,t}$	Firm i's total capitalized R&D at time t calculated as capitalized R&D divided by total assets adjusted for R&D capitalization[b] at time $t-1$
$RDeffort_{i,t}$	Firm i's total R&D expenditures at time t calculated as R&D expenses plus capitalized R&D expenditures
$RDexpensed_{i,t}$	Firm i's R&D expenses at time t calculated as expensed R&D divided by total assets adjusted for R&D capitalization[b] at time $t-1$
$RDint_{i,t}$	Firm i's R&D intensity at time t calculated as total R&D expenditures divided by sales
$RDint_{i,t}'$	Firm i's mean-centered R&D intensity at time t calculated as total R&D expenditures divided by sales less mean R&D intensity in our sample
$SIZE_{i,t}$	Firm i's size at time t measured by the natural logarithm of total assets adjusted for R&D capitalization[b,e]
$SUPERVISION_{i,t}$	Firm i's board independence at time t measured on a four-point scale, where $SUPERVISION_{i,t}$ equals 0/1/2/3 if no/at least 1/3 / ½ / at least ½ of board members are non-executives
$US_{i,t}$	Is a dummy variable indicating whether firm i is listed on a U.S. exchange at time t
$YEAR$	Is a vector of dummy variables indicating the year t

[a]Earnings before interest and taxes—(current capitalized R&D—current amortization/write-off of capitalized R&D)

[b]Total assets—(accumulated capitalized R&D—accumulated amortized R&D)

[c]Book value of equity—(accumulated capitalized R&D—accumulated amortized R&D)

[d]Net income—(current capitalized R&D—current amortization/write-off of capitalized R&D)

[e]For robustness checks: *SIZE* is alternatively measured as the natural logarithm of sales; *PROF* is alternatively measured as return on equity (net income adjusted for R&D capitalization divided by book value of equity adjusted for R&D capitalization[2])

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